National Aeronautics and Space Administration

Strategic Plan 2000

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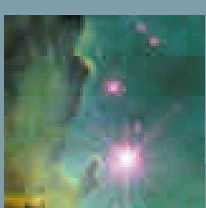
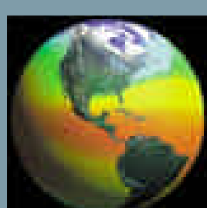


Space Science Enterprise



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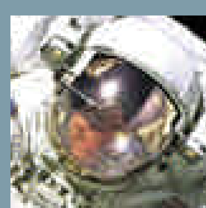

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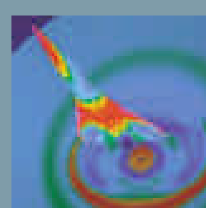


Aerospace Technology Enterprise

NASA Vision

NASA is an investment in America's future. As explorers, pioneers, and innovators, we boldly expand frontiers in air and space to inspire and serve America and to benefit the quality of life on Earth.

NASA Mission

- To advance and communicate scientific knowledge and understanding of the Earth, the solar system, and the universe
- To advance human exploration, use, and development of space
- To research, develop, verify, and transfer advanced aeronautics and space technologies

NASA's Core Values

■ Safety

NASA's mission success starts with safety. A commitment to safety permeates everything we do. We are committed to protecting the safety and health of the general public, the NASA workforce, and our high-value assets, on and off the ground.

■ People

Our greatest strength is our workforce, a team of highly qualified individuals that is representative, at all levels, of America's diversity. We foster a culture of trust, respect, teamwork, communication, creativity, equal opportunity, and empowerment.

■ Excellence

We are committed to excellence. We continuously improve our processes, products, and services to better serve our customers.

■ Integrity

We are honest and ethical in all that we do. We deliver on our commitments, and we are accountable for our performance.

Administrator's Strategic Outlook

"This Strategic Plan charts

For millennia, human beings have attempted to expand their horizons, both geographic and intellectual. Today, as we build the International Space Station, send probes beyond the solar system, and point our orbiting telescopes to the farthest reaches of the universe, we have progressed farther in this effort than our ancestors could have dreamed possible. I am proud to say that the United States leads this physical and intellectual expedition and that NASA has been, since its inception, at the forefront of the quest. This Strategic Plan charts our trajectory into the frontiers of flight, space, and knowledge. It explains our mission and why it is important for the Nation and for humanity.

Core Values

In conducting our work, we are guided at all times by four central values. The first of these is safety. NASA is committed to preserving the safety of the public, our astronauts, our employees, and our high-value assets. Every program described in this Plan has been reviewed with an eye toward further steps that we can take to ensure the safety of the outcome and all those who work so diligently for its success. We also hold as core values integrity

our trajectory into the frontiers of flight, space, and knowledge."

and a dedication to excellence. We highly value our people. These values are not only central to responsible public service; they are essential to the success of the challenging program charted in this Plan.

Fundamental Questions

At the heart of this plan are the six fundamental questions that appear on the next page. Some of these questions have been with us since the beginning of human consciousness; some are the product of the Space Age. They pertain to the nature of life and the universe, to the fundamental processes of existence, and to how we may apply human intelligence and determination to transcend the known boundaries of time and distance, improving our lives and those of our descendants. *These questions are the reason we undertake our mission.*

Our Program

This Strategic Plan includes both near-term priorities—flying the Space Shuttle safely and building the International Space Station—and longer-term investments in America's future—developing more affordable, reliable means of access to space and conducting cutting-edge scientific and technological research. It draws on NASA's strengths in engineering and science and reflects the revolutionary insights and capabilities on the horizon in areas such as biotechnology, nanotechnology, and information technology. It describes our vision for expanding air and space frontiers, serving America, and improving life on Earth.

NASA's past, present, and future success is in large part due to our outstanding civil service and contractor workforce. I am convinced that there is no more dedicated group of people serving any Government agency in the United States or the world.

We at NASA work to serve you, the public. Please send us your thoughts on NASA's Strategic Plan, and join us on our mission of discovery into the 21st century.

Daniel S. Goldin
NASA Administrator

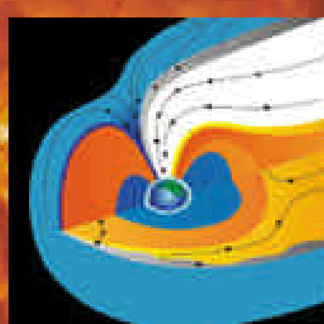
The Fundamental Questions

NASA seeks answers to fundamental questions of science and technology. These questions serve as the foundation for our goals.

Q:1 How did the universe, galaxies, stars, and planets form and evolve, and what is their destiny? How can our exploration of the universe and our solar system revolutionize our understanding of physics, chemistry, and biology?

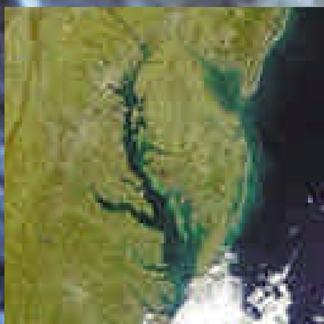
Q:2 Does life in any form, however simple or complex, carbon-based or other, exist elsewhere than on Earth? Are there Earth-like planets beyond our solar system?

Q:4 What is the fundamental role of gravity and cosmic radiation in vital biological, physical, and chemical systems in space, on other planetary bodies, and on Earth, and how do we apply this fundamental knowledge to foster a permanent human presence in space and to improve life on Earth?



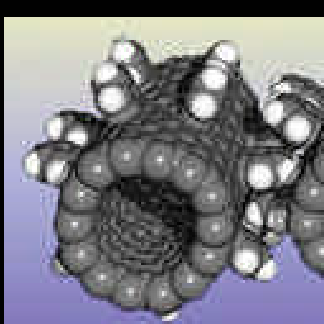
Q:5 How can we enable revolutionary technological advances to provide air and space travel for anyone, anytime, anywhere, more safely, more affordably, and with less impact on the environment, and improve business opportunities and global security?

Overview



Q:3 How can we utilize the latest findings about the Sun, Earth, and other planetary bodies to develop accurate, predictive environmental, weather, climate, natural disaster, and natural resource models to help ensure sustainable development and improve the quality of life on Earth?

Q:6 What cutting-edge technologies, processes, techniques, and engineering capabilities must we develop to enable our research agenda in the most productive, safe, economical, and timely manner? How can we most effectively transfer knowledge from our research and discoveries to benefit both commercial ventures and the quality of human life?



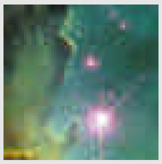
This Strategic Plan describes how we will pursue our vision, implement our mission, and seek answers to fundamental questions of science and technology that provide the foundation for our goals and objectives.

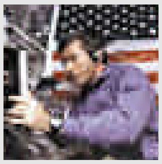
In addition to our vision and mission, NASA's strategic architecture consists of five Strategic Enterprises supported by four Crosscutting Processes. The Strategic Enterprises are NASA's primary mission areas. The Crosscutting Processes are common functional activities, coordinated across the Agency, and performed by all of the Strategic Enterprises. They are the processes that NASA uses to develop and deliver products and services to our customers. The Agency's goals and objectives are organized by Strategic Enterprise and Crosscutting Process.

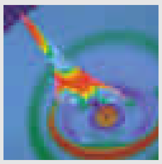
This Strategic Plan also includes roadmaps showing anticipated progress toward achieving NASA's goals and objectives over the next 25 years. The initial roadmap timeframe (2000–2005) covers near-term plans; this is the period required by the Government Performance and Results Act (GPRA) and the President's 5-year budget. Mid- and long-term plans are presented in the 2006–2011 and 2012–2025 timeframes. These roadmaps and the goals and objectives they support represent a balanced set of science, exploration, and technology development outcomes that we believe can be accomplished over the next 25 years.

Achieving our goals and objectives over the first quarter of the 21st century will contribute to national priorities: the protection of Earth's fragile environment, educational excellence, peaceful exploration and discovery, and economic growth and security.

Summary: NASA Goals and Objectives at a Glance

Enterprise	Goals	Objectives
 **Space Science** *Addresses Fundamental Questions 1, 2, & 6*	■ **Science:** Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life	■ Understand the structure of the universe, from its earliest beginnings to its ultimate fate ■ Explore the ultimate limits of gravity and energy in the universe ■ Learn how galaxies, stars, and planets form, interact, and evolve ■ Look for signs of life in other planetary systems ■ Understand the formation and evolution of the solar system and the Earth within it ■ Probe the evolution of life on Earth, and determine if life exists elsewhere in the solar system ■ Understand our changing Sun and its effects throughout the solar system ■ Chart our destiny in the solar system
	■ **Support Human Spaceflight:** Use robotic science missions as forerunners to human exploration beyond Low-Earth Orbit	■ Investigate the composition, evolution, and resources of Mars, the Moon, and small bodies ■ Develop the knowledge to improve space weather forecasting
	■ **Technology:** Develop new technologies to enable innovative and less expensive research and flight missions	■ Acquire new technical approaches and capabilities ■ Validate new technologies in space ■ Apply and transfer technology
	■ **Education and Public Outreach:** Share the excitement and knowledge generated by scientific discovery and improve science education	■ Share the excitement of space science discoveries with the public ■ Enhance the quality of science, mathematics, and technology education, particularly at the precollege level ■ Help create our 21st century scientific and technical workforce
 **Earth Science** *Addresses Fundamental Questions 3 & 6*	■ **Science:** Observe, understand, and model the Earth system to learn how it is changing and the consequences for life on Earth	■ Discern and describe how the Earth is changing ■ Identify and measure the primary causes of change in the Earth system ■ Determine how the Earth system responds to natural and human-induced changes ■ Identify the consequences of change in the Earth system for human civilization ■ Enable the prediction of future changes in the Earth system
	■ **Applications:** Expand and accelerate the realization of economic and societal benefits from Earth science, information, and technology	■ Demonstrate scientific and technical capabilities to enable the development of practical tools for public- and private-sector decision makers ■ Stimulate public interest in and understanding of Earth system science and encourage young scholars to consider careers in science and technology
	■ **Technology:** Develop and adopt advanced technologies to enable mission success and serve national priorities	■ Develop advanced technologies to reduce the cost and expand the capability for scientific Earth observation ■ Develop advanced information technologies for processing, archiving, accessing, visualizing, and communicating Earth science data ■ Partner with other agencies to develop and implement better methods for using remotely sensed observations in Earth system monitoring and prediction

Enterprise	Goals	Objectives
 **Biological and Physical Research** *Addresses Fundamental Questions 4 & 6*	■ **Enable Exploration:** Conduct research to enable safe and productive human habitation of space	■ Conduct research to ensure the health, safety, and performance of humans living and working in space ■ Conduct physical science research on planetary environments to ensure safe and effective missions of exploration ■ Conduct research on biological and physical processes to ensure future missions of exploration
	■ **Science:** Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology	■ Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community ■ Develop strategies to maximize scientific research output on the International Space Station and other space research platforms
	■ **Commerce:** Enable and promote commercial research in space	■ Assure that NASA policies facilitate industry involvement in space research ■ Systematically provide basic research knowledge to industry ■ Provide technical support for companies to begin space research ■ Foster commercial research endeavors with the International Space Station and other assets
	■ **Outreach:** Use space research opportunities to improve academic achievement and the quality of life	■ Engage and involve the public in research in space ■ Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets
 **Human Exploration and Development of Space** *Addresses Fundamental Questions 4 & 6*	■ **Explore the Space Frontier**	■ Invest in the development of high-leverage technologies to enable safe, effective and affordable human/robotic exploration ■ Conduct human health and engineering research on the International Space Station to enable exploration beyond Earth orbit ■ Enable human exploration through collaborative robotic missions ■ Define innovative human exploration mission approaches ■ Develop exploration/commercial capabilities through private-sector and international partnerships
	■ **Enable Humans to Live and Work Permanently in Space**	■ Provide and make use of safe, affordable, and improved access to space ■ Operate the International Space Station to advance science, exploration, engineering and commerce ■ Ensure the health, safety, and performance of humans living and working in space ■ Meet sustained space operations needs while reducing costs
	■ **Enable the Commercial Development of Space**	■ Improve the accessibility of space to meet the needs of commercial research and development ■ Foster commercial endeavors with the International Space Station and other assets ■ Develop new capabilities for human space flight and commercial applications through partnerships with the private sector
	■ **Share the Experience and Benefits of Discovery**	■ Engage and involve the public in the excitement and the benefits of—and in setting the goals for—the exploration and development of space ■ Provide significantly more value to significantly more people through exploration and space development efforts ■ Advance the scientific, technological and academic achievement of the Nation by sharing our knowledge, capabilities and assets

Enterprise	Goals	Objectives
 **Aerospace Technology** *Addresses Fundamental Questions 5 & 6*	■ **Revolutionize Aviation:** Enable a safe, environmentally friendly expansion of aviation	■ Increase Safety–Make a safe air transportation system even safer ■ Reduce Emissions–Protect local air quality and our global climate ■ Reduce Noise–Reduce aircraft noise to benefit airport neighbors, the aviation industry, and travelers ■ Increase Capacity–Enable the movement of more air passengers with fewer delays ■ Increase Mobility–Enable people to travel faster and farther, anywhere, anytime
	■ **Advance Space Transportation:** Create a safe, affordable highway through the air and into space	■ Mission Safety–Radically improve the safety and reliability of space launch systems ■ Mission Affordability–Create an affordable highway to space ■ Mission Reach–Extend our reach in space with faster travel
	■ **Pioneer Technology Innovation:** Enable a revolution in aerospace systems	■ Develop advanced engineering tools, processes, and culture to enable rapid, high-confidence, and cost-efficient design of revolutionary systems ■ Develop revolutionary technologies and technology solutions to enable fundamentally new aerospace system capabilities and missions
	■ **Commercialize Technology:** Extend the commercial application of NASA technology for economic benefit and improved quality of life	■ Facilitate the greatest practical utilization of NASA know-how and physical assets by U.S. industry

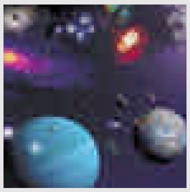
Crosscutting Processes

Goals	Objectives
■ **Manage Strategically:** Enable the Agency to carry out its responsibilities effectively, efficiently, and safely through sound management decisions and practices.	■ Protect the safety of our people and facilities, and the health of our workforce ■ Enhance the security, efficiency, and support provided by our information technology resources ■ Manage our fiscal and physical resources optimally ■ Achieve the most productive application of Federal acquisition policies ■ Invest wisely in our use of human capital, developing and drawing upon the talents of all our people
■ **Provide Aerospace Products and Capabilities:** Enable NASA's Strategic Enterprises and their Centers to deliver products and services to our customers more effectively and efficiently.	■ Enhance program safety and mission success in the delivery of products and operational services ■ Enable technology planning, development, and integration driven by Strategic Enterprise customer needs ■ Facilitate technology insertion and transfer, and utilize commercial partnerships in research and development to the maximum extent practicable ■ Improve NASA's engineering capability, to remain as a premier engineering research and development organization ■ Capture engineering and technological best practices and process knowledge to continuously improve NASA's program/project management
■ **Generate Knowledge:** Extend the boundaries of knowledge of science and engineering through high-quality research.	Improve the effectiveness with which we– ■ Acquire advice from diverse communities ■ Plan and set research priorities ■ Select, fund, and conduct research programs ■ Analyze and archive data and publish results
■ **Communicate Knowledge:** Ensure that NASA's customers receive information derived from the Agency's efforts in a timely and useful form.	■ Share with the public the knowledge and excitement of NASA's programs in a form that is readily understandable. ■ Disseminate scientific information generated by NASA programs to our customers. ■ Transfer NASA technologies and innovations to private industry and the public sector. ■ Support the Nation's education goals.

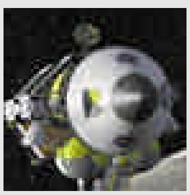
Summary: NASA High Level Roadmap—Contributions to National Priorities

NASA is an investment in America's future. As explorers, pioneers, and inspire and serve America and to benefit the quality of life on Earth.

Agency Mission



To advance and communicate scientific knowledge and understanding of Earth, the solar system, and the universe



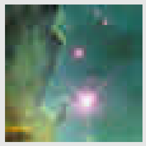
To advance human exploration, use, and development of space

To research, develop, verify, and transfer advanced aeronautics, space, and related technologies

Note:
This is a high-level summary of 25-year plans toward achievement of Enterprise goals and objectives.

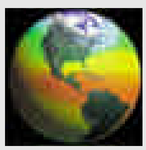
For detailed information, see the Enterprise Roadmaps in the Enterprise sections.

Enterprises / Near-term Plans 2000–2005



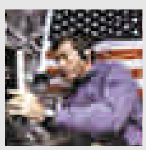
Space Science
Addresses Fundamental Questions 1, 2, & 6

- Study structure of collapsed objects and star forming nebulae, fine details of microwave background, early formation of galaxies and of stars, dust in other planetary systems, origins of gamma-ray bursts, and the composition of material between stars.
- Study Saturn, Titan, the composition of comets and asteroids, the orbits of Near-Earth Objects, and the surface and atmosphere of Mars; and return dust and solar wind samples.
- Study the Sun's atmosphere and interior, the interactions between the solar wind and Earth's magnetosphere, and solar coronal mass ejections.
- Develop advanced technologies in areas such as avionics, power sources, optics, bioassay technology, and sample return.



Earth Science
Addresses Fundamental Questions 3 & 6

- Measure global rainfall, uptake of atmospheric carbon dioxide (CO_2), atmospheric temperature and humidity, cloud properties, global ocean winds, and topography; and produce 3-D maps of the entire inhabited surface of the Earth. Expand use of commercial systems in collecting data.
- Employ high-performance computing to address Earth system modeling challenges; validate revolutionary technologies and satellite formation flying; and explore new instrument concepts.

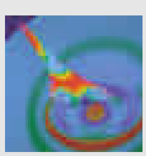


Biological and Physical Research
Addresses Fundamental Questions 4 & 6

- Identify mechanisms of health risk and potential physiological and psychological problems to humans living and working in space, and begin developing and testing countermeasures.
- Begin to conduct scientific and engineering research, and enable commercial research activities on the International Space Station (ISS).

Human Exploration and Development of Space
Addresses Fundamental Questions 4 & 6

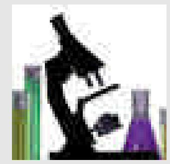
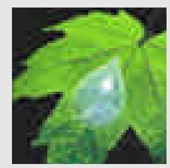
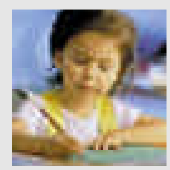
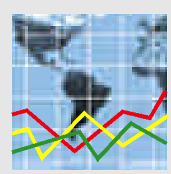
- Obtain key data for human mission design decisions from robotic science missions and develop technologies, interdisciplinary knowledge, and candidate approaches for human missions beyond Low-Earth Orbit (LEO) with a 5- to 10-fold reduction in costs.
- Complete ISS development to enable long-duration research.
- Create new approaches to collaborative partnerships with the private sector for the development of future human space exploration capabilities.



Aerospace Technology
Addresses Fundamental Questions 5 & 6

- Develop and demonstrate technologies to reduce the aviation accident rate, aircraft emissions, and noise. Improve terminal area productivity, support the Federal Aviation Administration's National Airspace System modernization, and develop technologies for general aviation aircraft and infrastructure improvements.
- Develop processes and technology improvements to support safer crewed launches and reduced cost of launches, and develop advanced space transportation concepts.
- Develop advanced engineering tools, processes, and design environments, and pioneer basic research in revolutionary technologies such as nanotechnology, information technology, and biotechnology.

innovators, we boldly expand frontiers in air and space to

Mid-term Plans 2006–2011	Long-term Plans 2012–2025	Contributions to National Priorities
■ Measure dark-matter, baryon, vacuum-energy densities, and gravitational waves from black holes; determine origin of cosmic rays and the role of active galactic nuclei in gamma-ray background; observe star birth in nebular cocoons; and spectroscopically survey for nearby Earth-like planets. ■ Learn about formation of the rocky planets, return a sample from a comet, investigate selected sites on Mars in detail, and search for liquid water ocean on Jupiter's moon Europa. ■ Expand understanding of space weather through solar, radiation belt, and ionospheric mappers. Study the detailed physics and structure of our magnetosphere and the outer solar atmosphere, and globally monitor the Sun. ■ Infuse revolutionary technologies into operational missions.	■ Resolve the infrared background and an accretion disk around the Milky Way black hole; measure the chemical composition of supernovas and the gas outside our solar system; and determine the prevalence of life-bearing planets around nearby stars. ■ Fly by Pluto and study Neptune and its satellite Triton. Search for evidence of biological activity on Europa, Titan, and other promising targets. Conduct advanced studies of Mars. ■ Complete our picture of the solar corona and develop an integrated understanding of space weather from a network of spacecraft. ■ Reap benefits of technology investment, including biological, information, and nanotechnology systems, enabling a virtual presence for autonomous scientific discovery.	 ***Increase the Understanding of Science and Technology***
■ Conduct research to achieve 7- to 10-day weather forecasts. Quantify the global fresh water cycle, variation in terrestrial and marine ecosystems, and forest and ocean carbon stocks. Assimilate ocean surface winds, tropospheric winds, and precipitation into climate and weather forecasting models. ■ Employ distributed computing and data mining techniques for Earth system modeling, implement autonomous satellite control and advanced instruments, and demonstrate a new generation of small instruments.	■ Conduct research to achieve 10- to 14-day weather and pollution forecasts, 10-year climate forecasts, 15- to 20-month El Niño forecasts, and 12-month rain rate. Assess sea-level rise and effects and predict regional impacts of decadal climate change. ■ Deploy cooperative satellite constellations, intelligent sensor webs, and advanced instruments for observations from liberation points (L1 and L2).	 ***Protect the Environment***
■ Understand the effects of long-duration space flight (e.g. radiation, gravity), validate countermeasures and technology, and begin developing countermeasures for long-duration space flight. ■ Test and validate technologies that can reduce the overall mass of human support systems by a factor of three (compared to 1990's levels). ■ Extend our understanding of chemical, biological, and physical systems.	■ Apply and refine countermeasures for safe, effective, and affordable long-duration human space flight. ■ Test and validate technologies for self-sustaining life support systems that can enable humans to live and work in space and on other planets. ■ Achieve a deep understanding of the role of gravity in complex chemical, biological, and physical processes.	 ***Create Education Excellence***
■ Establish robotic/engineering "outposts" at key sites and develop technologies and capabilities for 100-day human missions beyond LEO. Develop approaches to 1000-day missions with 10- to 20-fold cost reductions. ■ Complete research and technology validation (including ISS demos) of competing technologies for 100- to1000-day human missions. ■ Operate the ISS to advance science, exploration, engineering, and commerce. ■ Undertake pilot efforts leading to commercialization of ISS operations.	■ Conduct research and development to enable a further 2- to 4-fold reduction in costs for human exploration and complete development of safe, self-sufficient and self-sustaining capabilities for 1000-day class human-robotic missions beyond LEO. ■ Complete the transition of ISS to a customer-driven and commercial operation. ■ Extend scientific discovery on missions of exploration through the integrated use of human and robotic explorers.	 ***Peaceful Exploration and Discovery***
■ Reduce the aircraft fatal accident rate by 80%, nitrogen oxide (NO_X) emissions by a factor of 3, carbon dioxide (CO_2) emissions by 25%, and aircraft noise by a factor of 2. Double aviation system throughput and reduce inter-city doorstep-to-destination transportation time by 50% and explore integrated supersonic transport designs. ■ Reduce the risk of launch vehicle crew loss by a factor of 40, payload cost to LEO by a factor of 5, and travel time for planetary missions by a factor of 2. ■ Demonstrate advanced design tools, processes, and virtual environments in critical NASA engineering applications and integrate revolutionary aerospace system technologies.	■ Reduce the aircraft fatal accident rate by a 90%, NO_X emissions by a factor of 5, CO_2 emissions by 50%, and aircraft noise by a factor of 4. Triple aviation system throughput and reduce inter-city doorstep-to-destination transportation time by 67% and long-haul travel time by 50%. ■ Reduce the risk of launch vehicle crew loss by an additional factor of 10, payload cost to LEO by a factor of 10, and travel time for planetary missions by a factor of 10. ■ Demonstrate an integrated, high-confidence engineering environment and demonstrate new aerospace capabilities and new mission concepts in flight.	 ***Economic Growth and Security***

A plan for achieving our goals and objectives over

The Strategic Enterprises & Crosscutting Processes

NASA conducts its programs through Strategic Enterprises that constitute NASA's primary mission areas. These five Enterprises are supported by four processes that are common to each. These Crosscutting Processes provide key supporting functions that enable NASA's Enterprises to perform their mission activities.

The Enterprises seek answers to a wide range of questions derived from NASA's Fundamental Questions (see pages 4–5). The answers can both help explain our existence and improve the quality of our lives.

Space Science Enterprise (SSE)

The Space Science Enterprise seeks to chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planetary bodies, and life. The Enterprise asks basic questions that have eternally perplexed human beings: How did the universe begin and evolve? How did we get here? Where are we going? Are we alone? The Space Science Enterprise develops space observatories and directs robotic spacecraft into the solar system and beyond to investigate the nature of the universe.

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Earth Science Enterprise (ESE)

The Earth Science Enterprise aims to understand the Earth and its response to natural- and human-induced changes in order to improve prediction of climate, weather, and natural hazards, and help us to be responsible stewards of our planet for future generations. The Enterprise investigates Earth as an interacting system of atmosphere, oceans, land masses, and living beings affected by the Sun and other external phenomena. It inquires into the nature of the forces acting on and within the Earth system. Can we anticipate the Earth's response? How is the Earth changing? What are the consequences for life on Earth?

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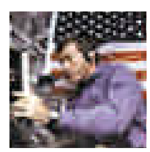
Biological and Physical Research Enterprise (BPR)



The Biological and Physical Research Enterprise conducts basic and applied research to support human exploration of space and to take advantage of the space environment as a laboratory. The Enterprise asks questions that are basic to our future: How can human existence expand beyond the home planet to achieve maximum benefits from space? How do fundamental laws of nature shape the evolution of life?

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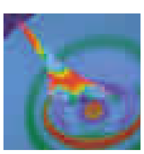
the first quarter of the twenty-first century.

Human Exploration and Development of Space Enterprise (HEDS)

The Human Exploration and Development of Space Enterprise seeks to expand the frontiers of space and knowledge by exploring, using, and enabling the development of space. HEDS asks questions to improve human possibilities both on Earth and in space. How do we design systems to make possible safe and efficient human exploration and commercial development of space? What are the resources of the solar system? Where are they? Are they accessible for human use? How can we ensure that humans can be productive in and beyond Earth orbit? HEDS is building the International Space Station to provide a continuously operating research platform and to prepare the way for robotic and human exploration even farther into space.

See Page 32

Aerospace Technology Enterprise (AST)



The Aerospace Technology Enterprise works to maintain U.S. preeminence in aerospace research and technology. The Enterprise aims to radically improve air travel, making it safer, faster, and quieter as well as more affordable, accessible, and environmentally sound. The Enterprise is also working to develop more affordable, reliable, and safe access to space; improve the way in which air and space vehicles are designed and built; and ensure new aerospace technologies are available to benefit the public.

See Page 38

Means and Strategies to Achieve our Goals

The primary means and strategies that NASA will use to achieve its Enterprise goals and objectives are described in the text of each Enterprise section. Supporting means and strategies as well as NASA-wide operational procedures are described in the **Crosscutting Processes** section of this plan:

Manage Strategically–Describes critical management functions
Provide Aerospace Products and Capabilities–Describes NASA's Agency-wide technology and program management strategies
Generate Knowledge–Explains shared research strategies
Communicate Knowledge–Defines NASA's communication strategies

See Pages 44–47

Synergy and Partnerships

One means to NASA goal achievement is to leverage **Cross-Enterprise Synergies**. Another key strategy for mission accomplishment is cooperation with interagency and international partners;this is described under **Partnerships**.

See Pages 48–55

External Factors

Key factors external to NASA could significantly affect achievement of our goals. Because so many of NASA's programs consist of long-term, cutting-edge research, the same factors affect most of NASA's goals. This plan discusses those factors in the **External Assessment**. Where some Enterprise goals are contingent on certain factors more than on others, these factors are identified in the Enterprise sections that follow.

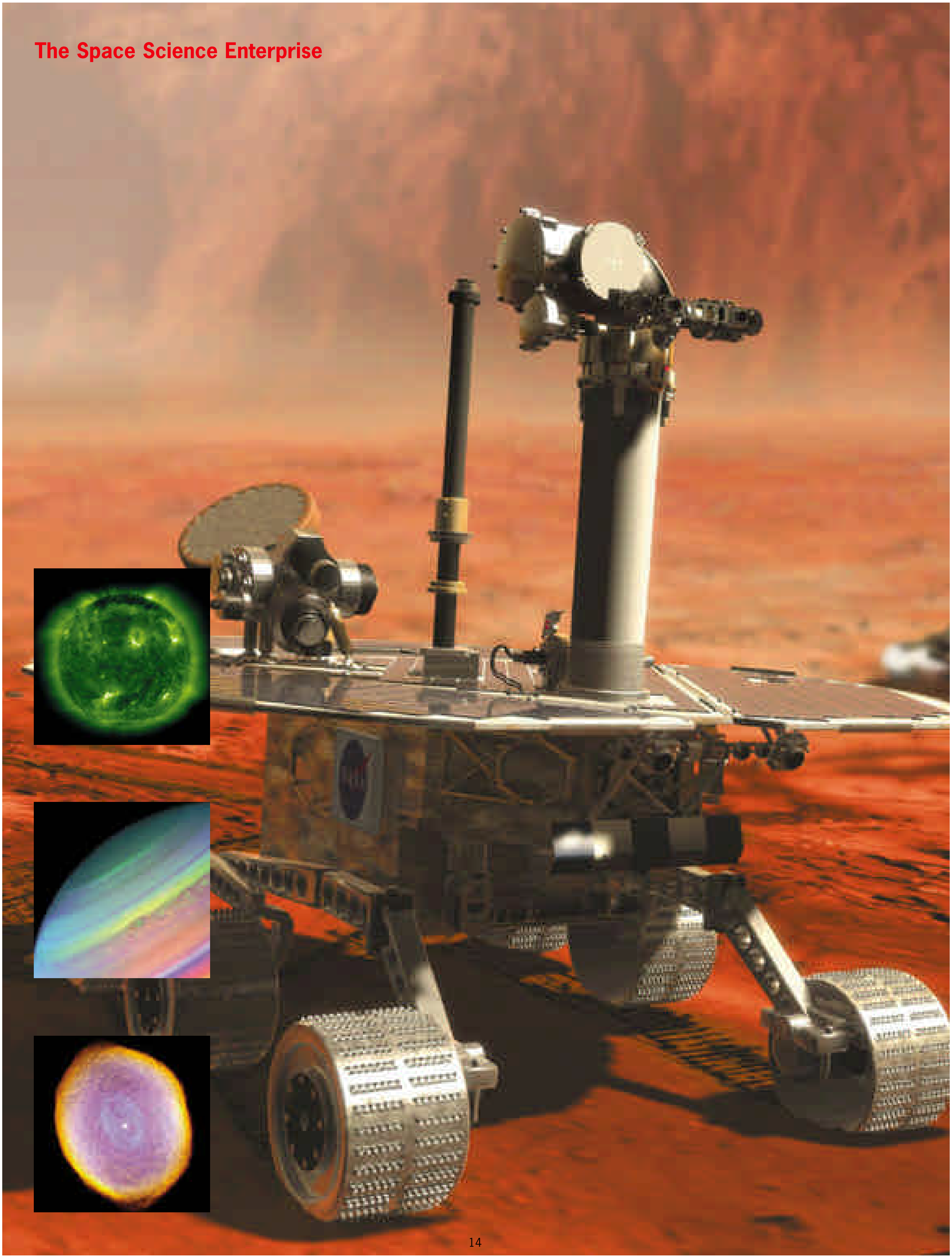
See Page 56

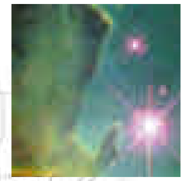
NASA and the Strategic Management System

Our plans are built around understanding and satisfying the requirements of **NASA's Customers,** as determined by **Consultation** with those customers. We achieve our goals and objectives through the **NASA Team and Organization**, using **NASA's Strategic Management System** that we designed to integrate Strategic Planning with **Performance Planning** and **Evaluating** and **Reporting Performance**. These mechanisms play an important part in achieving our goals and objectives. Our resources strategy is described in detail in the NASA budget and is summarized in the **Resources** section.

See Pages 60–64

The Space Science Enterprise



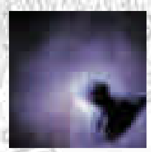


Mission: Discover how the universe began and evolved, how we got here, where we are going, and whether we are alone.

Human beings have always tried to understand their place in the universe. How did we come to exist on Earth? What is the nature of the stars and our galaxy? How far does the universe extend? Increasingly, we are finding scientific answers to these questions. Space probes, space observatories, and computer modeling are revealing a universe that our ancestors never imagined. NASA has been at the forefront of this historic quest for comprehension. The answers may not only explain our past but may also help us understand our future.

Goal 1

Science: Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life.



The following are key examples of the many programs that will address Space Science Enterprise (SSE) objectives.

Structure of the universe: What is the size, shape, age, and energy content of the universe? In the beginning, the universe was smooth and almost featureless, but today it is richly diverse. This diversity includes invisible "dark matter," black holes, and other exotic phenomena. To investigate the transition, an improved cosmic microwave background mapper soon will study how clusters of galaxies emerged in the very early universe. A joint far-infrared telescope mission with the European Space Agency (ESA) will observe dusty galaxies undergoing intensive star formation. Another space-based observatory will view cosmic x-rays to learn how clusters of galaxies evolve.

Gravity and energy in the universe: The universe is filled with invisible magnetic fields and traversed by cosmic rays of unknown origin. A Space Station experiment will analyze the composition of cosmic rays, attempt to identify their origin, and derive information about the pervasive magnetic fields. NASA will, in the middle of this decade, use the Gamma-ray Large Area Space Telescope to detect gamma rays—very short wavelength electromagnetic radiation—emitted by black holes and other unidentified sources. An ambitious joint mission with the ESA will measure gravitational radiation, opening a new window on the universe.

The genesis and evolution of galaxies, stars, and planets: How did the first condensations of matter after the Big Bang lead to today's universe? To explore this mystery, NASA and our international partners will use new infrared satellite telescopes to investigate the formation of stars and planets and the early evolution of luminous galaxies. An aircraft-based telescope will supply complementary data. But to detect galaxies in their infancy requires an even larger telescope with superb resolution. Near the end of this decade, the Next Generation Space Telescope will peer into the clouds harboring the youngest stars and planets to reveal their location, mass, chemical composition, and dynamics.

2003 Mars Exploration Rover—the first robotic field geologist on Mars.

Top: Solar and Heliospheric Observatory image of the Sun's corona.

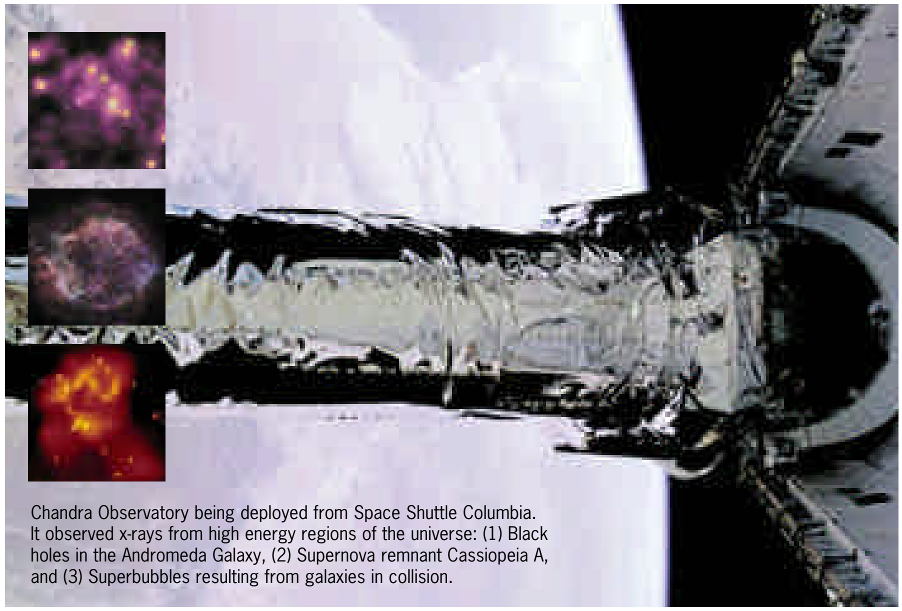
Middle: Voyager 2 image of Saturn.

Bottom: Hubble Space Telescope image of the Spirograph Nebula.

Life on planets of other stars: What are the planets of other stars like? Are there many of them? Do any of them resemble Earth? With the Space Interferometry Mission, NASA will, by the end of this decade, be able to search hundreds of stars to detect planets almost as small as Earth. In the longer term, to find out whether these planets can support life, a large interferometric telescope, the Terrestrial Planet Finder, will use spectral analysis to identify planets that have warm atmospheres containing significant amounts of water or oxygen, which could indicate biological activity.

The formation and evolution of our solar system and the Earth: The Earth and other bodies in the solar system formed at about the same time and from the same material—a disk of gas and dust encircling the Sun. But the outer "gas giant" planets are very different from the "rocky" planets of the inner solar system. And the inner planets, although similar in size, have dramatically differing atmospheres and surface properties. Why? Mars is the most Earth-like planet in the solar system, with a mysterious past probably very unlike its dry and airless present. It appears to have once had abundant water, a key ingredient of life on Earth. To try to confirm this, NASA will continue to pursue a long-range series of Mars orbiters and landers, including two landers in the 2003 launch opportunity and eventually a sample return.

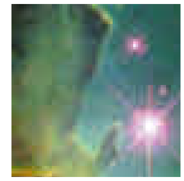
The beginning of life on Earth and whether life exists elsewhere in our solar system: Beyond Mars, there is evidence for the presence of liquid water in the outer solar system as well. The Galileo mission's observations of Jupiter's moon Europa suggest there is water beneath its icy crust. To pursue this dramatic but inconclusive lead, NASA plans a Europa Orbiter and possibly eventually a Europa Lander. Scientists hypothesize that comets impacting Earth may have delivered the materials needed for the origin of life: water, atmospheric gases, and perhaps organic chemicals. To investigate this, NASA will fly missions to study the composition of asteroids, comets, and interplanetary dust. NASA's Astrobiology Initiative probes the central questions of the origin of life on Earth by tracing the existence of biologically



Chandra Observatory being deployed from Space Shuttle Columbia. It observed x-rays from high energy regions of the universe: (1) Black holes in the Andromeda Galaxy, (2) Supernova remnant Cassiopeia A, and (3) Superbubbles resulting from galaxies in collision.

Basic Principles and Mutually Reinforcing Science Objectives

The Space Science Enterprise has developed uniform principles to guide program decisions. These principles include using scientific merit as the primary criterion in selecting investigations, inviting the non-NASA research community to participate actively in space science activities, maintaining essential technical capabilities at the NASA Centers, and basing international cooperation on maximum scientific return. Another key principle is the requirement that every flight program or research effort must help implement specific science objectives. Every SSE program supports a science objective, and many in fact support more than one objective. For example, in attempting to identify the structure of the universe some programs such as the Hubble Space Telescope, also tell us more about the evolution of galaxies, stars, and planets. Programs that seek to understand the science of our changing Sun also support human space flight by discovering how to protect astronauts from solar radiation.



critical elements from the first moments of the universe to the evolution of living beings.

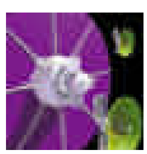
Our changing Sun and its effects throughout the solar system: NASA is conducting a series of Solar Terrestrial Probe missions to understand the intrinsic nature of the Sun and its effects on the Earth, on other planets, and on the space between them. For example, NASA will examine the physics of the magnetosphere, the outermost region of the Earth's atmosphere where the solar wind collides with the Earth's magnetic field. Other missions, including a cooperative mission with Japan, will study the basic dynamics of our Sun and the connection between the solar wind and the Earth's magnetosphere and ionosphere (the atmospheric region next closest to the Earth). The Living with a Star program will study the causes of solar activity and its impact on Earth and on human exploration. Solar flares can incapacitate Earth-orbiting satellites, disrupt electrical power grids, and expose astronauts to health hazards; understanding them is crucial to quality of human life both on Earth and in space.

Our destiny in the solar system: Missions to the Moon, Mars, and near-Earth asteroids will help us assess potential destinations and resources for human exploration. NASA's strategy to realize this goal is to build on recent missions such as Lunar Prospector, which returned evidence of water on the Moon, and the Mars Surveyor program, and to develop missions to Earth-approaching asteroids to evaluate their resource potential.

Goal 2
Support Human Space Flight: Use robotic science missions as forerunners to human exploration beyond low-Earth orbit.

To help pave the way for human exploration missions, SSE will investigate the composition, evolution, and resources of Mars, the Moon, and other potential destinations. SSE will also develop knowledge needed to improve space weather forecasting, enabling better prediction and mitigation of the radiation to which humans might be exposed. SSE partners with the Human Exploration and Development of Space (HEDS) Enterprise to provide information essential to ensure that humans can venture safely and productively into space.

Goal 3
Technology: Develop new technologies to enable innovative, less expensive flight missions.



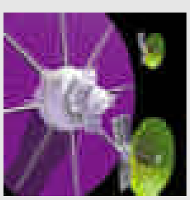
Advanced technologies allow NASA to conduct missions with lower mass, power, and other resource requirements. This reduces the time and cost of achieving space science goals. Advanced technologies can often also improve the probability of mission success and increase the mission's scientific return. The SSE technology program will continue to acquire new technical approaches, validate new spacecraft capabilities, and apply and transfer technology.

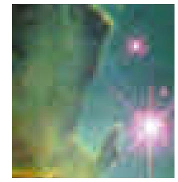
Goal 4
Education and Public Outreach: Share the excitement and knowledge generated by scientific discovery and improve science education.

Space science has great potential to strengthen America's interest in science and to improve the quality of U.S. science, mathematics, and technology education. NASA aims to share the excitement of space science missions with the public, enhance U.S. education, and help create the outstanding present and future scientific and technical workforce our Nation needs. Virtual exploration and the Internet now offer new dramatic, accessible ways for SSE to share its findings and activities. NASA will continue to use these and other methods to incorporate education and outreach into every SSE mission and research program, increase the proportion of space scientists directly involved in precollege education, improve access to space science information, and promote participation of under-served groups.

External Factors—Achievement of Space Science goals and objectives is particularly contingent on external factors pertaining to technological advance and unexpected discoveries. (See External Assessment)

The Space Science Enterprise—Roadmap

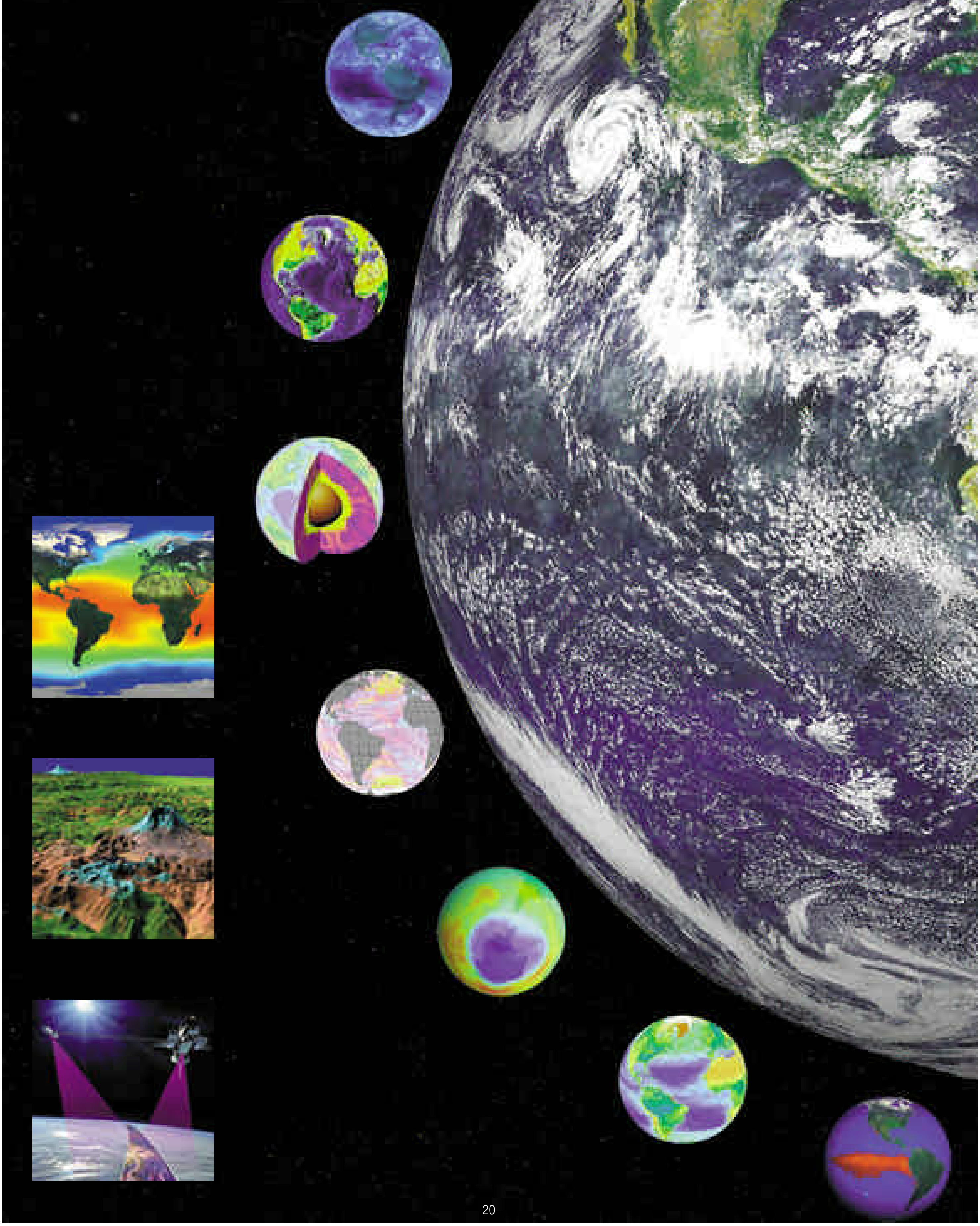
Space Science Goals		Objectives	Near-term Plans 2000–2005
	**Science:** Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life	■ Understand the structure of the universe, from its earliest beginnings to its ultimate fate ■ Explore the ultimate limits of gravity and energy in the universe ■ Learn how galaxies, stars, and planets form, interact, and evolve ■ Look for signs of life in other planetary systems ■ Understand the formation and evolution of the solar system and the Earth within it ■ Probe the evolution of life on Earth, and determine if life exists elsewhere in the solar system ■ Understand our changing Sun and its effects throughout the solar system ■ Chart our destiny in the solar system	■ Measure fine details of microwave background ■ Observe structure of collapsed objects, and determine origins of gamma-ray bursts ■ Observe in infrared the earliest stages of stellar birth, determine composition of material between stars, and learn about early formation of galaxies and of stars in the galaxy ■ Analyze dust in other planetary systems, and obtain precise distances and velocities for 40 million nearby stars ■ Investigate Saturn, its rings, and moon Titan. Analyze the structure and composition of comets, understand the history of Mars, and return dust and solar wind samples ■ Conduct laboratory and field research on the origin of life on Earth (Astrobiology Initiative), and search for water on Mars ■ Study the dynamics of the Sun's atmosphere and interior, research the interactions between the solar wind and Earth's magnetosphere, and view solar coronal mass ejections in 3-D ■ Obtain images of the Earth's magnetosphere during geomagnetic storms, search for evidence of water on Mars, and characterize the number and orbits of Near Earth Objects
	**Support Human Space Flight:** Use robotic science missions as fore-runners to human exploration beyond Low-Earth Orbit	■ Investigate the composition, evolution, and resources of Mars, the Moon, and small bodies ■ Develop the knowledge to improve reliability of space weather forecasting	■ Explore the surface and atmosphere of Mars, survey the structure and composition of asteroids, and investigate the composition and structure of comets ■ Analyze the dynamics of the Sun's atmosphere and interior and obtain 3-D images of solar coronal mass ejections
	**Technology:** Develop new technologies to enable innovative and less expensive flight missions	■ Acquire new technical approaches and capabilities ■ Validate new technologies in space ■ Apply and transfer technology	■ Develop technologies such as radiation-survivable miniaturized spacecraft avionics, advanced non-solar power sources, precision optics, planetary sampling mechanisms, bioassay technology, and sample return systems ■ Test two independent spacecraft flying as an optical interferometer, and demonstrate flying three subminiature spacecraft as a single system
	**Education and Public Outreach:** Share the excite-ment and knowl-edge generated by scientific discovery and improve science education	■ Share the excitement of space science discoveries with the public. ■ Enhance the quality of science, mathematics, and technology education, particularly at the precollege level ■ Help create our 21st century scientific and technical workforce	■ Integrate education and enhanced public understanding of science into our missions and research programs, establish strong and lasting partnerships between the space science and education communities, and provide ready access to the products of space science education and outreach programs

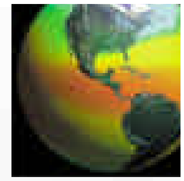


Mid-term Plans 2006–2011	Long-term Plans 2012–2025
■ Measure dark-matter, baryon, and vacuum-energy densities, and determine total mass in clusters of galaxies ■ Determine how much of the cosmic gamma-ray background is due to active galactic nuclei, determine origin of cosmic rays, and measure gravitational waves from black holes ■ Observe very remote galaxies and determine their chemical composition, see into nebular cocoons to analyze the birth of stars in our galaxy, and determine the distribution and nature of dominant components of our galaxy and how they evolved with time ■ Detect Earth-size planets around nearby stars, and spectroscopically survey the nearest 200 stars for planets with Earth-like atmospheres ■ Learn about formation of the rocky planets, investigate the nature of the early solar system by returning a sample from a comet, and continue exploration of Mars ■ Continue research on life on Earth and potential biological history of Mars, and search for liquid water ocean on Jupiter's moon, Europa ■ Understand the detailed physics of our magnetosphere, study physics of the outer Solar atmosphere by flying through it, analyze detailed structure of the magnetosphere using a constellation with many microsatellites ■ Expand understanding of space weather using solar, radiation belt, and ionospheric mappers ■ Investigate selected sites on Mars in detail	■ Resolve the infrared background to learn the history of energy generation and research formation of chemical elements in the universe ■ Resolve an accretion disk around the massive black hole at the center of our Milky Way galaxy through x-ray interferometry ■ Obtain x-ray images and composition of chemical elements created in supernovas, and directly measure the composition of the gas outside our solar system with an interstellar probe ■ Determine prevalence of life bearing planets by obtaining detailed images of planets around nearby stars and looking for clear spectroscopic evidence of biological activity ■ Complete reconnaissance of the Solar System by flying by Pluto, studying Neptune and its satellite Triton, and conducting advanced studies of Mars ■ Search for evidence of biological activity on Europa, study the prebiotic chemistry of Saturn's moon Titan, and explore promising solar system targets to search for evidence of past or present life. Integrate solar system findings with the search for life in other planetary systems ■ Understand the effect of solar activity on layers of Earth's atmosphere, and complete our picture of the solar corona by observing it from the solar poles ■ Develop an integrated understanding of space weather by deploying a network of spacecraft throughout the Earth-Sun system and clarify the larger context for life in our solar system with missions to Europa, Titan, or other sites of potential prebiotic chemistry
■ Continue exploration of Mars, ascertain the presence of a liquid water ocean on Europa, and return a sample from a comet nucleus ■ Refine our predictive understanding of solar activity by investigating the dynamics of the solar atmosphere and interior and globally monitoring the Sun system	■ Continue exploration of the inner solar system in support of possible human exploration ■ Evolve the scientific basis for a predictive understanding of space weather
■ Infuse revolutionary technologies into operational missions. Includes autonomous lrobotics and sample return; gossamer apertures for imaging and spectroscopy by great observatories, constellations of cooperating nanosatellites, bioinformatics, and advanced propulsion and optical communication systems for ultra-deep space probes	■ Reap benefits of technology investment including: bio-info-nano systems enabling a virtual presence for autonomous scientific discovery, self-replicating/repairing systems for exploration, featherweight multifunctional structures for interstellar voyages, and cooperative human/robotic systems for permanent habitation of Mars
■ Implement and enhance education and outreach strategies and develop the capability to allow the public to participate "virtually" in the adventure of exploring other worlds	■ Devise and implement new approaches to working with the education community and to bringing the results of our programs to the public

Note: Plans that contribute to multiple objectives may appear twice.

The Earth Science Enterprise





Mission: Develop a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations.

Early human societies developed theories about the Earth and the environment. Each had its own explanation for the oceans, the wind, storms, the changing seasons. Over time, through theory, observation, and experiment, we have refined our understanding of our home planet. NASA has been a leader in this effort, developing instruments that led to the first weather satellites and the first satellites to map the Earth's surface. Today, NASA is working together with other agencies from around the world to gather and analyze global data from space, making possible an understanding of the Earth system that is attainable in no other way. This data is allowing us increasingly to predict our planet's behavior.

Large Earth image based on geostationary satellite imagery and Landsat data. Smaller Earth images are Earth views using different data and focusing on different phenemona.

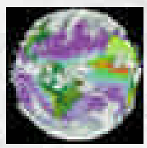
Top: Sea surface temperature.

Middle: Mount St. Helens.

Bottom: Shuttle Radar Topography Mission.

Goal 1

Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth.



Five key science questions are at the heart of this goal:

1. How is the global Earth system changing?
2. What are the primary causes of change in the Earth system?
3. How does the Earth system respond to natural and human-induced changes?
4. What are the consequences of change in the Earth system for human civilization?
5. How well can we predict future changes in the Earth system?

The Earth Science Enterprise (ESE) seeks to answer these questions through data gathering and analysis. In the near term, NASA is conducting the first-ever systematic survey of practically every aspect of the Earth system. The effort relies on measurements from the Earth Observing System (EOS) satellites and the series of smaller, experimental Pathfinder spacecraft. Data are collected on variables including clouds, precipitation, atmospheric temperature and humidity, chemicals in the stratosphere and troposphere, radiation, land cover and vegetation, fires, volcanoes, land and sea surface temperature, ocean surface winds, and ice and snow cover. Aircraft and other field campaigns validate and supplement the satellite data. NASA then examines the data, using large-scale computer models to discern patterns and trends among variables. Near-term results will include better inputs for weather and climate prediction, and 3-D maps of the entire inhabited surface of the Earth.

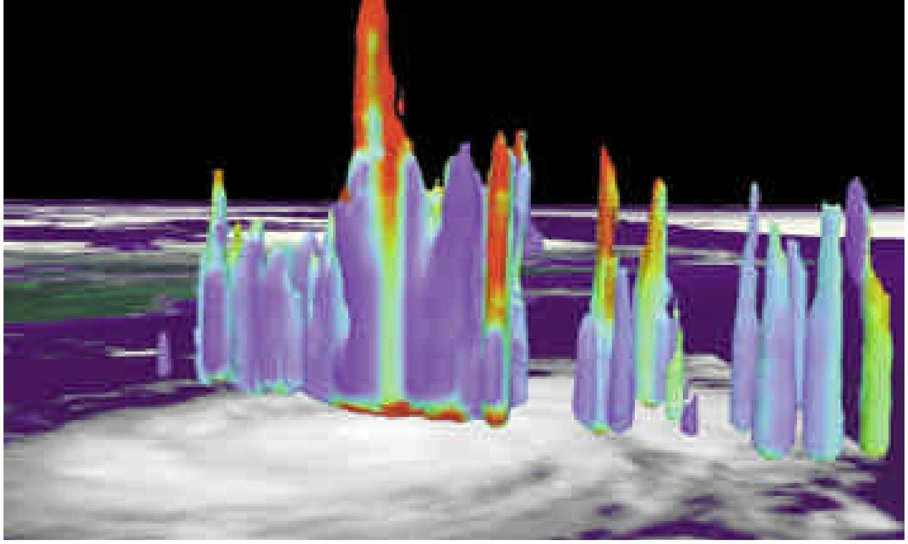
In the mid-term, ESE will develop even more advanced instruments and modeling techniques. Results of better observations will include interactive models of climate change impacts, vastly better identification of how human and natural forces affect Earth, and more complete data, especially global winds and precipitation. These data will both improve climate prediction and extend weather forecasts from the current 3 to 5 days to 7 to 10 ten days. To achieve these benefits, NASA is planning the suite of Earth-observing satellites that will succeed the first EOS series described above. These include a land remote sensing capability to succeed Landsat 7 and a joint satellite with the National Oceanic and Atmospheric Administration (NOAA) and the

Department of Defense (DOD). This cooperative effort will provide NASA with climate research data while demonstrating advanced instruments for future joint civilian/military weather satellites.

The Earth System

The Earth is a system. Phenomena in the oceans affect the atmosphere, the Earth's interior affects the surface, land use affects weather—the interactions among these factors and others such as solar radiation, the polar ice caps, and winds are myriad and exceedingly complex. Using global observations of these variables, we can model and increasingly predict the behavior of our planet. The potential benefits are enormous. They include increasingly accurate long-term weather and even seasonal and annual climate forecasts, with benefits in sectors such as agriculture, construction, shipping, and travel. Better understanding and prediction may lead us to significantly reduce losses from natural disasters such as hurricanes, floods, earthquakes, and wildfires. Accurate assessment of Earth resources can strengthen water resource management and land use planning. It can help industry more quickly and efficiently locate and recover Earth resources. It will also allow us to better understand how human activities affect Earth, so that governments, businesses, and citizens can make informed decisions that will sustain the Earth's resources for ourselves and for future generations.

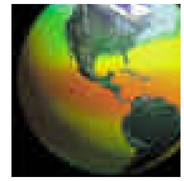
Visualization of precipitation rates at various altitudes reveals the anatomy of Hurricane Bonnie. Researchers use the precipitation radar to determine the distribution of energy within the hurricane.



Long-term benefits of the ESE program will include 10-day weather and pollution forecasts, 5-day volcanic eruption advance warnings, 15- to 20-month El Niño forecasts, and 10-year predictions of the regional impact of climate change. To obtain the observations needed for this level of prediction, NASA envisions an intelligent network of multiple observation types and vantage points using new technologies such as tiny, inexpensive microsatellites and nanosatellites. These systems will be reconfigurable and autonomous, with overlapping measurements for calibration and validation. ESE's technology investment strategy over the next 5 to 10 years focuses on the instrument, spacecraft, and information technologies needed to make this future possible.

Goal 2
Expand and accelerate the realization of economic and societal benefits from Earth science, information, and technology.

NASA is working to help translate Earth science results into tangible benefits to help citizens in their everyday lives. For example, through its Applications, Commercial, and Education effort and the Commercial Remote Sensing Program, ESE cooperates with the U.S. Department of Agriculture and growers' associations to apply Earth science knowledge to agriculture. ESE has partnered with the U.S. Department of Transportation to apply remote sensing data to highway routing. With the

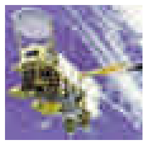


Federal Emergency Management Agency ESE is mapping flood plains to reduce life and property losses from severe storms. NASA works with industry and State and local governments to help commercialize Earth science information,technologies, and products; transfer them to everyday use; educate the public about them; and train a new generation of remote sensing experts. NASA partnerships also facilitate use of Earth science technologies and results by, for example, community-based environmental organizations and multijurisdictional hazard mitigation programs.

NASA envisions that over the next 5 to 10 years the private sector will be able to supply increasing amounts of the Government's remote sensing data needs. National standards will bring interoperability to the remote sensing industry. Real-time, remote sensing knowledge will become available via the Internet. Linked models of the land, ocean, and atmosphere will vastly improve resource planning in both the public and private sectors.

In addition to transferring Earth science technology for practical applications, NASA is working to make Earth science information readily accessible as a standard, essential part of education. This effort comprises kindergarten through high school, colleges and universities, and adult education venues. The goal is to encourage students to consider science and technology careers and to increase the Earth science literacy of all Americans.

Goal 3
Develop and adopt advanced technologies to enable mission success and serve national priorities.

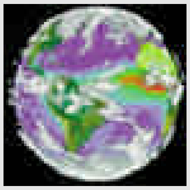


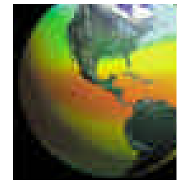
NASA will improve observational capabilities through the development of small, smart detectors that require less payload space; passive systems with lower energy requirements; designs that allow simpler calibration, integration, and operation; and small self-deploying instrument packages. Strategies to achieve these advances include the Instrument Incubator Program, which competitively selects innovative instrument concepts and sponsors their maturation to the instrument designs of the future. The New Millennium Program identifies, develops, and tests in orbit promising future instrument technologies to verify whether they are ready for full-scale deployment as operational instruments. NASA is pursuing architecture improvements that include intelligent platform and sensor control, better space/ground communications, linking multiple data sets to view the Earth as a system, and increasing the number of data providers and data users in Government and the private sector.

A key strategy for achieving NASA's Earth Science objectives is to forge partnerships with service providers who develop NASA discoveries into new products and services for the Nation. NASA has traditionally pioneered experimental spacecraft and instruments and then turned them over to operational agencies. Perhaps the best example of this is NASA's long partnership with NOAA. For decades, NASA has developed the Nation's weather satellite technologies and then transitioned them to NOAA to provide the space-based weather observations used in national forecast models. NASA is now developing instruments for the future converged DOD/NOAA weather satellite system mentioned above.

External Factors—Achievement of Earth Science goals and objectives is particularly contingent on the legislative and policy framework, partnerships, technological advances and unexpected discoveries. (See External Assessment)

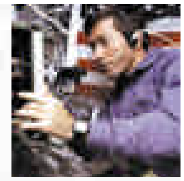
The Earth Science Enterprise—Roadmap

Earth Science Goals	Objectives	Near-term Plans 2000–2005
 **Science:** Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth	■ Discern and describe how the Earth is changing ■ Identify and measure the primary causes of change in the Earth system ■ Determine how the Earth system responds to natural and human-induced changes ■ Identify the consequences of change in the Earth system for human civilization ■ Enable the prediction of future changes in the Earth system	■ Establish a benchmark for global rainfall ■ Estimate uptake of atmospheric CO_2 from global measurements of the terrestrial biosphere ■ Provide precise global measurements of atmospheric temperature and humidity ■ Make global measurements of cloud properties to determine Earth's response to solar radiation ■ Measure global ocean winds and topography to improve accuracy and length of weather prediction and drive models of ocean impacts on climate change ■ Produce 3-D maps of the entire inhabited surface of the Earth
 **Applications:** Expand and accelerate the realization of economic and societal benefits from Earth science, information, and technology	■ Demonstrate scientific and technical capabilities to enable the development of practical tools for public and private sector decision-makers ■ Stimulate public interest in and understanding of Earth system science and encourage young scholars to consider careers in science and technology	■ Demonstrate applications of geospatial data to areas such as: agriculture, forestry, and urban and transportation planning ■ Expand use of commercial systems in collecting Earth system science data ■ Collaborate with educators to develop new curricula support materials using Earth science data and discoveries
 **Technology:** Develop and adopt advanced technologies to enable mission success and serve national priorities	■ Develop advanced technologies to reduce the cost and expand the capability for scientific Earth observation ■ Develop advanced information technologies for processing, archiving, accessing, visualizing, and communicating Earth science data ■ Partner with other agencies to develop and implement better methods for using remotely sensed observations in Earth system monitoring and prediction	■ Implement satellite formation flying to improve science return, and New Millennium Program to validate revolutionary technologies in space ■ Explore new instrument concepts for next decade missions ■ Employ high-performance computing to address Earth system modeling challenges ■ Collaborate with operational agencies in mission planning, development, and operations



Mid-term Plans 2006–2011	Long-term Plans 2012–2025
■ Achieve a quantitative understanding of the global fresh water cycle ■ Quantify with a “high” or “moderate” degree of confidence all the principal Earth system forcing and response factors ■ Quantify the variation and trends in terrestrial and marine ecosystems; estimate carbon stocks in forests and oceans globally ■ Run fully interactive ecosystem-climate models to assess impacts of climate change ■ Assimilate ocean surface winds, tropospheric winds, and precipitation into climate and weather forecasting models	■ Assess sea-level rise and effects ■ Demonstrate capability for– • 10-year climate forecasts • 12-month rain rate • 10-day forecast of pollution alerts • 5-day volcanic eruption prediction • 15- to 20-month El Nino forecasts ■ Predict regional impacts of decadal climate change
■ Conduct research to achieve 7- to 10-day weather and seasonal precipitation prediction capability; enable broad use of data in precision agriculture ■ Enable an effective mix of private, Government, and international data sources and users ■ Incorporate Earth system science into education curricula at the K–12 and university levels	■ Conduct research to achieve 10- to 14-day weather and annual precipitation prediction capability ■ Enable wide spread commercial supply and use of global environmental data; integration of environmental information and economic decision making ■ Produce the next generation of Earth system scientists
■ Develop and implement autonomous satellite control ■ Demonstrate a new generation of small, highly capable active, passive, and in situ instruments ■ Transition advanced instruments for systematic measurements to operational systems ■ Employ distributed computing and data mining techniques for Earth system modeling ■ Develop high data rate communications and on board data processing and storage	■ Deploy cooperative satellite constellations and intelligent sensor webs ■ Design instruments for new scientific challenges; deploy advanced instruments to migrate selected observations from geosynchronous and Low-Earth Orbits to libration points (L1 and L2) ■ Develop a collaborative synthetic environment to facilitate understanding and enable remote use of models and results ■ Collaborate in an international global observing and information system; improve operational systems with new technology

The Biological and Physical Research Enterprise



Mission: Use the synergy between physical, chemical, and biological research in space to acquire fundamental knowledge and generate applications for space travel and Earth applications.

Throughout most of history, humans have viewed gravity as an inescapable constant. Gravity has also profoundly affected how life on Earth has evolved. But new access to the space environment is now allowing scientists to conduct unprecedented research in low gravity, opening a new window on longstanding questions of science and technology. Space also poses physical challenges to space explorers, who must find ways to withstand space environment hazards for which humanity's evolution on Earth never prepared them. NASA's Biological and Physical Research Enterprise (BPR) conducts interdisciplinary fundamental and applied research to address the opportunities and challenges of human exploration of space.

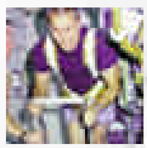
Astronaut Catherine Coleman handles a mouse ear plant on Space Shuttle Columbia as part of the Plant Growth Investigations in Microgravity (PGIM) experiment.

Top: Senator John Glenn works with the Advanced Organic Separation (ADSEP) experiment on Discovery's November 1998 mission.

Middle: Carbon "nanotubes," measured in billionths of a meter, may support an array of new technologies for human space flight.

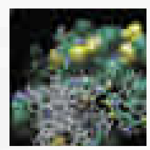
Bottom: Combustion research—a candle flame in reduced gravity assumes a spherical shape.

Goal 1
Conduct research to enable safe and productive human habitation of space.



Space flight exposes humans to physiological and psychological health risks from radiation, reduced gravity, and isolation. BPR will coordinate research in the physical and biological sciences with biomedical applications to develop methods that will reduce these threats to human health in space and planetary environments. BPR will use results from the continuum of research, from fundamental through applied, to design strategies to maintain health, safety, and performance in the hostile environment of space. In addition to controlling the physical changes that seriously threaten space travelers'health, this Enterprise will conduct research to develop the means to remotely provide crew medical care. BPR will also conduct research on technology for efficient, self-sustaining, life-support systems to provide safe, hospitable environments for space exploration. NASA will team with other research agencies, the private sector, and academia to establish the scientific foundation for cutting-edge, molecular-scale biomedical technologies for use on Earth and in space.

Goal 2
Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology.



The space environment offers a unique laboratory in which to study chemical, physical, and biological processes. Researchers will take advantage of this environment to conduct experiments that are impossible on Earth. For example, most combustion processes on Earth are dominated by the fact that hot gases rise. In space, this is not the case, and hidden properties of combustion emerge. Results from this research promise to improve fire safety, fuel efficiency, and pollution control. Materials scientists will study the role of gravity in important industrial processes. Their results may lead not only to the formation of new materials impossible to produce on Earth, but also to better control of Earth-based processes to obtain

Cross-Disciplinary Investigation

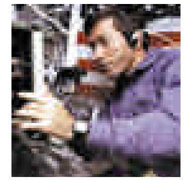
NASA's Biological and Physical Research Enterprise creates unique cross-disciplinary research programs, bringing the basic sciences of physics, biology, and chemistry together with a wide range of engineering disciplines. The synergy and vigor achieved in this interdisciplinary enterprise will help the Agency meet its needs for new approaches to long-term mission requirements, and ensure that NASA's contribution to fundamental research will be at the leading edge of science. Concurrently, the Enterprise will encourage applications to develop new commercial products and services.

Advances in biology have opened an era of unprecedented gains in understanding of living systems, giving us the ability to modify and, to a limited extent, to mimic the functions of biological systems. These new capabilities have only begun to achieve their potential impact on medicine and technology. When combined with progress in the physical sciences over the past century and with revolutionary capabilities in information technology, the synthesis of biology, physics, chemistry, and engineering will transform the technological foundations not only of the space program but also of our society.

improved products. Physicists will take advantage of microgravity to study exotic forms of matter that are better handled in space. Biological research will investigate the role of gravity in life processes. The Enterprise will conduct research to integrate our understanding of the role of gravity in the evolution, development, and function of living organisms and in basic biological processes. The knowledge derived from BPR's diverse research will not only inform and expand scientific understanding, but will also contribute fundamental knowledge NASA needs to achieve its strategic goals.

Goal 3
Enable and promote commercial research in space.

The Enterprise will provide knowledge, policies, and technical support to facilitate industry investment in space research. NASA has designated 30 percent of ISS resources for commercial utilization. NASA will continue to enable commercial researchers to take advantage of space flight opportunities for proprietary research. The commercial sector will grow to become the premier mechanism for applying space knowledge to benefit



the American people. Commercial applications of space knowledge will generate new products, new jobs, and new spin-off companies. At the same time, commercial investment will play an ever-increasing role in enabling the exploration and development of space.

Goal 4
Use space research opportunities to improve academic achievement and the quality of life.

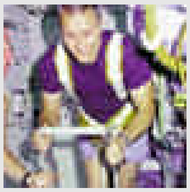
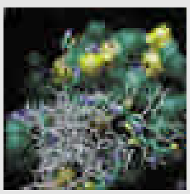
BPR seeks to use its research activities to encourage educational excellence and to improve scientific literacy from primary school through the university level and beyond. The Enterprise delivers value to the American people by facilitating access to the experience and excitement of space research. NASA seeks to engage the commercial sector in exploiting the economic benefits of space. We also strive to involve society as a whole in the transformations that will be brought about by research in space.

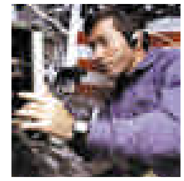
External Factors—Achievement of Biological and Physical Research goals and objectives is particularly contingent on external factors pertaining to unexpected discoveries and markets. (See External Assessment)

Left: Payload specialist Roger Crouch conducts research on the Microgravity Space Lab 1 Space Shuttle Mission.

Above: Plant growth chamber, NASA Johnson Space Flight Center. BPR seeks to create technologies for closed loop life support systems.

The Biological and Physical Research Enterprise—Roadmap

Biological and Physical Research Goals	Objectives	Near-term Plans 2000–2005
 **Enable Exploration:** Conduct research to enable safe and productive human habitation of space	■ Conduct research to ensure the health, safety, and performance of humans living and working in space ■ Conduct physical science research on planetary environments to ensure safe and effective missions of exploration ■ Conduct research on biological and physical processes to enable future missions of exploration	■ Identify mechanisms of health risk and potential physiological and psychological problems to humans living and working in space, and begin developing and testing countermeasures ■ Conduct research in analog test beds and on orbit to enhance medical care for human space flight ■ Test and validate technologies that can reduce the overall mass of human support systems by a factor of 2 (compared to 1990's levels) ■ Begin developing interdisciplinary knowledge (e.g., biology, physics, materials) to support safe, effective, and affordable human/robotic exploration
 **Science:** Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology	■ Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community ■ Develop strategies to maximize scientific research output on the International Space Station and other space research platforms	■ Conduct scientific and engineering research and enable commercial research activities on the ISS to enrich health, safety, and the quality of life on Earth ■ Establish dynamic research partnerships with the scientific community to open new fields of research in chemical, biological, and physical processes, including– • Gravity effects on cellular genomics and mechanisms • Structure of biological materials • Safe and efficient combustion processes • Atomic physics investigations probing relativity and new forms of matter ■ Working with the HEDS Enterprise, identify important science objectives for 100-day class human missions
 **Commerce:** Enable and promote commercial research in space	■ Assure that NASA policies facilitate industry involvement in space research ■ Systematically provide basic research knowledge to industry ■ Provide technical support for companies to begin space research ■ Foster commercial research endeavors with the International Space Station and other assets	■ Provide periodic reports on potential applications of space knowledge and possibilities for industry partnerships ■ Review and make recommendations for changes to NASA commercial policies ■ Advocate policy, legislative, and engineering actions to facilitate privately funded commercial space development ■ Create new approaches to collaborative partnerships with the private sector for the development of future BPR Enterprise capabilities
 **Outreach:** Use space research opportunities to improve academic achievement and the quality of life	■ Engage and involve the public in research in space ■ Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets	■ Expand public and K–12 educational access to mission research information ■ Work with colleges and universities in the conduct of biological and physical space research



Mid-term Plans 2006–2011	Long-term Plans 2012–2025
■ Understand the effects of long-duration space flight (e.g., radiation), validate countermeasures and technology and begin developing countermeasures for long-duration space flight ■ Test and validate technologies that can reduce the overall mass of human support systems by a factor of three (compared to 1990's levels) ■ Collaboratively with the space science community, conduct research on ambitious robotic missions to acquire needed research data	■ Apply and refine countermeasures for safe, effective, and affordable long-duration human space flight ■ Conduct life-support and biological technology research to support HEDS in enabling a further 2- to 4-fold reduction in costs for ambitious long-term human exploration ■ Test and validate technologies for safe, self-sufficient, and self-sustaining life support systems that can enable humans to live and work in space and on other planets—independent from Earth-provided logistics—for extended periods
■ Extend our understanding of chemical, biological and physical systems, including– • Long-duration research on material/related topics • Multigenerational studies of organisms • Expand our understanding of the effects of varying levels of gravity on biological processes • Expand our understanding of molecular structures, cells, biological processes, etc., and use that understanding to make human spaceflight safer and more productive • Use our understanding of the fundamental principles that control and energetic processes to enhance spacecraft fire safety and open technology opportunities ■ Working with the HEDS Enterprise, identify important science objectives for 1000-day class human missions ■ Incorporate expanded telescience capabilities into ISS research activities ■ Initiate research missions using small autonomous spacecraft for biological research and technology test beds	■ Achieve a deep of understanding of the role of gravity in complex chemical, biological, and physical processes ■ Use NASA leadership in integrated chemical, biological, and physical scientific research to open technology opportunities for revolutionary approaches to new human and robotic missions
■ Transition mature ISS commercial products and technologies to full private sector financing ■ Encourage and enable new commercial products, services, and technologies in space	■ Utilize services of commercially owned and/or operated space facilities for space research ■ Encourage and enable commercial activities in the continuing exploration of space
■ Expand partnerships with colleges, universities, and K–12 to share NASA's discoveries and increase student interest in space research and science	■ Further develop academic and outreach programs to take advantage of advanced long-duration space research

The Human Exploration and Development of Space Enterprise

Mission: Expand the frontiers of space and knowledge by exploring, using, and enabling the development of space for human enterprise.

For millennia, humans have dreamed of voyaging into space. In the past century, the dream became a reality. In orbiting laboratories, humans now perform unprecedented scientific research, achieve new medical discoveries, and prepare the way for yet further ventures. Based on the history of exploration and discovery, what we learn in space is almost certain to open avenues of knowledge undreamed of today. Some of these may dramatically affect the well-being and perhaps even the long-term survival of humanity. The United States through NASA has led this pioneering effort in the past and is now enlisting the cooperation of the international community to explore and develop space for the benefit of all humankind.

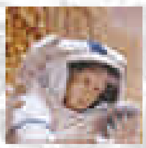
Construction of the International Space Station began in 1998, when the crew of the Space Shuttle Endeavour joined the U.S.-built Unity node to the Russian-built Zarya module.

Top: Astronaut Mae C. Jemison performs the Autogenic Feedback Training Experiment inside the Spacelab science module.

Middle: Spacewalking astronaut Jerry Ross conducting "extravehicular activities" (EVA).

Bottom: Field geologist Dean Eppler conducts tests of the mobility of an experimental space suit.

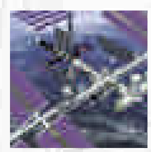
Goal 1
Explore the Space Frontier.



NASA is working to establish safe, self-sustaining systems enabling humans to live and work independent from Earth for extended periods in space, and in the long-term, on other planets and their moons. NASA is establishing the inter-disciplinary knowledge base needed for safe, effective, and affordable robotic and human exploration. The Human Exploration and Development of Space (HEDS) Enterprise will utilize Biological and Physical Research Enterprise research in biology, physics, and materials necessary to reduce threats to human health from space radiation, low gravity, and the psychological effects of isolation and remoteness from Earth. Working with the Space Science Enterprise, HEDS will obtain data needed to design future space vehicles and infrastructures, including information on the space environment in general and on the resources, environment, and weather of potential landing sites. NASA plans to establish continuing robotic operations at key sites ("outposts") to acquire data and conduct experiments before human explorers arrive.

Other key strategies for exploration include a continuing emphasis on technological innovation to reduce mission costs and cooperation with industry to identify aspects of missions having commercial potential. NASA will work with industry and other partners including international space agencies to develop affordable mission technologies. In the long term, HEDS envisions human-robotic missions with international partners to outposts beyond low-Earth orbit.

Goal 2
Enable Humans to Live and Work Permanently in Space.



NASA is working to enable and establish a permanent, productive human presence in space, in which new technologies and new ways of doing business afford unprecedented commercial and scientific opportunities. As a first step, NASA will upgrade the Space Shuttle to improve safety and reliability and will continue to transition it from Government to contractor operations. At the same time, HEDS will work with the Aerospace Technology Enterprise and with industry to develop technologies for future launch and in-space transportation.

Design Reference Points

NASA's Human Exploration and Development of Space Enterprise aims to develop the capability to send humans safely and productively ever farther into our solar system. HEDS has identified three phases for this capability development. Each phase is characterized by Design Reference Points that entail progressively greater challenge, farther distance, and longer duration.

The near-term focus is on Low-Earth Orbit (LEO) missions, specifically Space Shuttle voyages of up to 2 weeks and International Space Station (ISS) missions of 30 to 90 days. These prepare the way for the mid-term phase, missions beyond LEO lasting about 100 days. These could include missions to libration points or on the Moon. Libration points are where the gravitational forces of two bodies, for example Earth and the Moon or the Earth and the Sun,are in balance. They can be advantageous for observatories and experiments and as launching sites for voyages farther into space. NASA envisions placing advanced telescopes or other infrastructures at the Earth-Moon and Earth-Sun libration points. Other 100-day missions could explore the lunar surface to expand knowledge and build experience for future explorations. In the long term, NASA seeks the capability for complex missions of 500 to 1000 days or longer. These could include missions to Mars and to asteroids to investigate the origins and presence of life and to locate economically valuable materials. NASA may eventually be capable of missions lasting 2000 days or more, making possible journeys to the outer solar system—to the moons of Jupiter and beyond.

View out the aft flight deck window of the Space Shuttle.

The aim is to advance systems for both commercial and Government use that are much safer and more economical than current capabilities.

While developing future space transportation mechanisms, NASA will in the next few years complete, with international participation, the International Space Station (ISS), and initiate the Station-based scientific research efforts described above. A key HEDS strategy is to eventually commercialize ISS. NASA will continue to design strategies to maintain health, safety, and performance in the hostile environment of space. NASA will also develop efficient, self-sustaining, life-support systems providing safe, hospitable environments for space exploration.

Goal 3
Enable the Commercial Development of Space.

NASA is working to formulate and advocate the policy, legislative, and engineering framework needed to facilitate privately funded commercial space activities. This includes both removing barriers and providing incentives. One strategy to achieve this is creation of a Non-Governmental Organization (NGO) to facilitate commercial activities. Through the NGO, HEDS will

offer a significant and increasing share of U.S. payload accommodations to commercial ventures so that ISS can function as a genuine commercial research and development (R&D) testbed. NASA has released a pricing policy, structure, and schedule for these commercial activities.

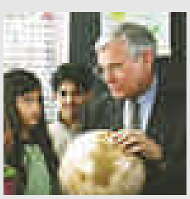
Over time, the public share of costs of ISS endeavors will decrease until ISS becomes a commercially operated scientific laboratory and business venue. In the far term, NASA plans to transfer responsibility for all human space flight systems in Earth orbit to the private sector and purchase needed services commercially as NASA turns its focus to the higher-risk farther reaches of the space frontier. Throughout this process, NASA will work with industry to identify the commercial potential of future missions and to conduct cooperative projects to develop new capabilities and reduce Government costs.

Goal 4
Share the Excitement and Benefits of Discovery.

Human space flight has for decades inspired young people to undertake careers in science and technology, benefiting both themselves and our Nation. NASA is working to engage the public in the excitement and benefits of space, both by providing opportunities to participate "firsthand" in missions and by improving education related to exploration, science, and technology. NASA plans to use telepresence and virtual reality technologies to allow the public to travel along to robotic "outposts" and with astronauts on missions beyond Earth orbit. NASA is committed to improving the scientific literacy of all Americans and reaching groups traditionally underrepresented in the sciences and technology. Strategies include bringing "firsthand" mission participation to the classroom, collaborations with museums, and helping educators strengthen curricula by incorporating more science, mathematics, technology, and engineering.

External Factors—Achievement of HEDS goals and objectives is particularly contingent on external factors pertaining to partnerships with other nations and to markets. (See External Assessment)

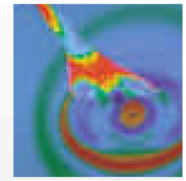
The Human Exploration and Development of Space Enterprise—Roadmap

Goals	Objectives	Near-term Plans 2000–2005
 **Explore the Space Frontier**	■ Invest in the development of high-leverage technologies to enable safe, effective, and affordable human/robotic exploration ■ Conduct engineering research on the International Space Station to enable exploration beyond Earth orbit ■ Enable human exploration through collaborative robotic missions ■ Define innovative human exploration mission approaches ■ Develop exploration/commercial capabilities through private sector and international partnerships	■ Obtain key data for human mission design decisions from collaboration with robotic science missions ■ Identify and evaluate candidate approaches for 100- to 1000-day human missions capable of a 5- to 10-fold cost reduction*—while increasing safety and effectiveness ■ Develop and validate competing technologies for human missions beyond Low-Earth Orbit (LEO) in cooperation with other Agencies, international partners, and U.S. industry *compared with 1990's studies
 **Enable Humans to Live and Work Permanently in Space**	■ Provide and make use of safe, affordable and improved access to space ■ Operate the International Space Station to advance science, exploration, engineering, and commerce ■ Ensure the health, safety, and performance of humans living and working in space ■ Meet sustained space operations needs while reducing costs	■ Complete transition of the Space Shuttle to Space Flight Operations Contract (SFOC) and undertake needed upgrades ■ Complete ISS development and pursue creation of a non-Governmental Organization (NGO) to simplify processes for and/costs of access to space ■ Conduct exploration and engineering research—and enable scientific and commercial research—activities on the ISS to enrich health, safety, and the quality of life on Earth
 **Enable the Commercial Development of Space**	■ Improve the accessibility of space to meet the needs of commercial research and development ■ Foster commercial endeavors with the International Space Station and other assets ■ Develop new capabilities for human space flight and commercial applications through partnerships with the private sector	■ Formulate and advocate policy, and legislative and engineering actions, to facilitate privately funded commercial space development ■ Identify jointly with industry the commercial potential of concepts for 100-day class missions and establish cooperative R&D to develop candidate technologies ■ Create new approaches to collaborative partnerships with the private sector for the development of future HEDS Enterprise capabilities
 **Share the Experience and Benefits of Discovery**	■ Engage and involve the public in the excitement and the benefits of—and in setting the goals for—the exploration and development of space ■ Provide significantly more value to significantly more people through exploration and space development efforts ■ Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets	■ Expand public access to HEDS mission information (especially from ISS) by working with industry to create media projects and public engagement initiatives ■ Work with colleges and universities in the conduct of HEDS research and technology for future exploration

Mid-term Plans 2006–2011	Long-term Plans 2012–2025
■ Continue development of competing breakthrough technologies in cooperation with partners, including U.S. industry ■ Collaboratively with the space science community, conduct ambitious robotic/engineering missions to establish “outposts” at key sites in space/on planetary surfaces ■ Identify and evaluate 1000-day mission candidate approaches capable of a 10- to 20-fold reduction in cost ■ Develop capabilities for 100-day class human-robotic missions beyond LEO in collaboration with international partners, and (where appropriate) facilitate privately funded industry development of these capabilities	■ Finalize candidate architectures and begin R&D to enable a further 2- to 4-fold* reduction in costs for ambitious long-term human exploration, making use of revolutionary technologies and both new and existing infrastructures ■ Complete development of safe, self-sufficient, and self-sustaining capabilities for 1000-day class human-robotic missions to a previously established site beyond LEO, in collaboration with international partners *compared with Mid-term targets
■ Strengthen partnerships with industry to ensure ISS access and pursue Shuttle upgrades until a credible replacement is available ■ Operate the ISS to advance science, exploration, engineering, and commerce; undertake pilot efforts leading to commercialization of ISS operations ■ Expand collaborative research on the ISS that will further human exploration of the solar system ■ Complete research and technology validation (including ISS demos) of competing technologies for 100- to 1000-day human missions	■ Partner with industry and the Aerospace Technology Enterprise to reduce HEDS Enterprise space transportation costs more than 5-fold* while increasing safety ■ Complete the transition of ISS to a customer-driven commercial operation ■ Complete development of systems and perfect countermeasures that can enable humans to live and work in space and on other planets for extended periods ■ With the Space Science Enterprise, extend scientific discovery on missions of exploration through the integrated use of human and robotic explorers *compared with Mid-term targets
■ Identify (jointly with industry) the commercial potential of concepts for 1000-day missions and establish cooperative R&D projects to develop candidate technologies ■ Foster new approaches to collaborative partnerships with the private sector to develop future HEDS capabilities	■ Transfer responsibility for human space flight systems in Earth orbit to the private sector and dedicate NASA R&D to the risks of expanding the frontier ■ Transition the ISS to the private sector as a fee-for-service scientific lab, technology testbed, and business venue with all customers trading in a free market economy ■ Buy commercial services for HEDS, including: commercial communication for 1000-day missions, and from the ISS commercial operator—to validate technologies for evolutionary 1000+ day missions
■ Broaden “firsthand,” interactive participation in exploration, e.g., outpost 100-day class human missions ■ Expand partnerships with colleges/universities and K–12 to share NASA’s discoveries and increase student interest in space exploration and science.	■ Expand public engagement through interactive participation in 1000-day class human missions • Expand public engagement through continuing initiatives that allow meaningful participation in ongoing or planned HEDS missions beyond LEO ■ Update HEDS academic programs to focus on ambitious integrated human-robotic exploration missions

Note: Plans that contribute to multiple objectives may appear twice.

The Aerospace Technology Enterprise



Mission: Maintain U.S. preeminence in aerospace research and technology.

In 1903, the Wright brothers realized the ancient dream of human flight. Since then, air travel has changed our lives. Average citizens casually complete in hours transcontinental and transoceanic journeys that previously required weeks or months of dangerous travel. Meanwhile, technology developments challenge the boundary between air and space in a quest that will someday make even farther, faster travel a reality for everyone. NASA has since its inception played a key role in aerospace technology development. Today, NASA's Aerospace Technology Enterprise (AST) conducts research to make possible safer, cleaner, quieter, and faster air travel and routine space transportation; it also develops and commercializes innovative technologies.

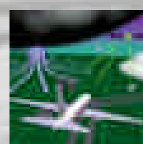
Future aerospace vehicles can be enabled by NASA technology. Clockwise from top: advanced small aircraft, advanced rotorcraft, tiltrotor aircraft used as an emergency medical transport, a 300 passenger supersonic transport, a 600 passenger subsonic transport (a Blended wing body concept), and a reusable launch vehicle for transporting cargo to orbit.

Top: Artist's concept of a human exploration mission to Mars being powered by nuclear thermal rocket propulsion.

Middle: Simulation of a jet engine high pressure compressor increases design confidence and cuts the hardware development cycle time in half.

Bottom: Artificial vision technology for increased airport safety and efficiency.

Goal 1
Revolutionize aviation: Enable the safe, environmentally friendly expansion of aviation.



NASA aims to improve global civil aviation by improving passenger safety, throughput, and mobility and by reducing aircraft emissions and noise.

Increase Safety: The projected increase in the number of air travelers will make the need for improved aviation safety even more pressing. AST aims to reduce the aircraft fatal accident rate such that, even with air traffic growth, the number of accidents will decline. Strategies to achieve this objective include technologies to identify, understand, and correct aircraft system problems before they lead to accidents, technological interventions to address specific accident causes such as human error and weather, and aircraft modifications to minimize injury in the event of an accident. These efforts will rely on NASA partnerships with the Federal Aviation Administration (FAA) and the aviation community.

Reduce Emissions: NASA is committed to helping the aviation community achieve significant reductions in nitrogen oxides and carbon dioxide. Without effective action, carbon dioxide emissions from aviation are projected to increase, and potentially accelerate climate change. Similarly, nitrogen oxides generated during airport operations are a suspected cause of ground-level ozone, contributing to air pollution problems. NASA's goal is to reduce the impact of aviation-related emissions even given the projected increase in aircraft operations. Strategies center on developing more energy-efficient aircraft, engines, and air traffic management tools.

Reduce Noise: Aircraft noise is a quality-of-life issue to millions living near airports. Noise-related concerns constrain the aircraft industry by inhibiting airport construction and expansion, preventing full use of U.S. aerospace products in the world market, and rendering some aircraft obsolete. Noise concerns also limit available flights, which affects consumer choice, convenience, and cost. NASA's strategies for noise reduction focus on quieter airframes and engines and on improved procedures such as glide slopes and flight paths that reduce ground-level noise. NASA will continue working with the FAA and industry to accelerate technology development and adoption for a win-win solution, for both the aviation and airport neighbor communities.

Increase Capacity: NASA is working to safely move significantly more passengers through the Nation's air transportation system with fewer

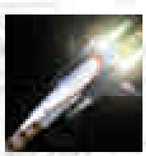
delays. This is critical if the U.S. is to accommodate the continued increases in air travel that are projected. Key strategies for achieving this objective include: improvements to aircraft and the air traffic control system to enable the movement of passengers more quickly and reliably, day and night in all weather conditions without compromising safety; better information exchange across the national airspace system; new aircraft and airport configurations that would make it possible to transport more people without requiring new infrastructure; and new concepts for better use of the airspace itself. This effort employs close collaboration with the FAA and U.S. air carriers to integrate NASA technologies into actual operations.

Technology Contributions to National Priorities and Critical Partnerships

NASA develops long-term, high-payoff aerospace technologies that improve our quality of life by strengthening the Nation's economy, improving the environment, and contributing to national security. Our aerospace technology goals and objectives have been designed to focus on outcomes for the Nation. It is NASA's unique role to provide the technology to enable these outcomes. But we cannot achieve these outcomes alone. We rely on our partners, the Federal Aviation Administration (FAA), the Department of Defense (DOD), U.S. industry, and the university community to help establish requirements, participate in our technology development efforts, and most important, to implement those technologies in civil and military air and space transportation products. As members of the National Science and Technology Council (NSTC), NASA, FAA, and DOD participated in the development of joint national aviation goals. NASA's Aerospace Technology Goals contribute to these national aviation goals, described in the NSTC's "National Research Plan for Aviation Safety, Security, Efficiency and Environmental Compatibility." The technology advances that NASA is pursuing are essential if the Nation is to achieve these goals.

Increase Mobility: NASA aims to improve the mobility of U.S. citizens by reducing travel time for both short and long journeys. This requires a wide range of innovations and improvements. For example, NASA is working on methods to integrate small aircraft and all public use landing facilities into the National Air Transportation System to significantly reduce travel time into and out of every community. This will require improvements to both aircraft and the network of small airports. For long journeys, affordable supersonic travel will be essential, but the technological challenges are significant. NASA is working to resolve specific technology problems such as sonic booms, engine noise, and emissions, as well as assessing new vehicle-design concepts.

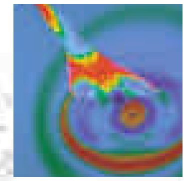
Goal 2
Advance space transportation: Create a safe, affordable highway through the air and into space.



Exploring and developing the space frontier will require safer, more affordable, and much faster space transportation capabilities. NASA is coordinating all of its space transportation efforts under a single investment strategy—the Integrated Space Transportation Plan (*See Cross-Enterprise Synergies*). The Plan supports technical risk reduction activities in partnership with industry. These activities will lead to a competition in 2005 for full-scale launch vehicle development. These vehicles, combined with NASA-unique hardware, will enable NASA to meet all of its launch needs using commercially competitive, privately owned and operated Earth-to-orbit launch vehicles by 2010. NASA's space transportation technology objectives are as follows.

Mission Safety: NASA's objective is to make space travel as safe as today's air travel, moving space travel out of the realm of the extraordinary into the mainstream. NASA is working to reduce the risk of crew loss by designing crew escape systems and by developing for inherent vehicle safety and reliability through fewer parts and more robust subsystems. Developing tools to enable end-to-end computer design and testing of an entire vehicle and its mission, including life cycle risk assessment, will dramatically increase mission safety. In addition, integrating intelligence into vehicle systems will result in improved vehicle health management and self-repair. Safe space launch and travel will help make space accessible to all and will enhance development of the commercial space sector.

Mission Affordability: NASA aims to reduce the cost of taking payloads to orbit without compromising safety or reliability. This will require improved concepts for reusable launch vehicles as



well as advanced launch systems and launch operations. NASA's strategy is to accelerate progress toward a second-generation reusable launch vehicle in the near-term while fostering the development of more advanced commercial launch systems in the longer term. Opportunities for near-Earth operations and commercialization will be made available by new propulsion systems, improved materials and structures for lightweight, durable in-space transportation vehicles, and reusable systems for traveling between Earth orbits. Both affordability and safety are essential if we are to realize a dynamic, productive space market. By developing capabilities for both medium/heavy and small payloads, including systems to transfer payloads between Earth orbits, NASA will create a true "Highway to Space."

Mission Reach: This objective aims to develop light, fast space propulsion systems that will reduce travel times. Technology focuses include small systems for deep space missions conducted by the Space Science Enterprise, missions to other planets, and breakthrough propulsion technologies to allow us to eventually reach other stars within a human's lifetime.

Goal 3
Pioneer Technology Innovation: Enable a revolution in aerospace systems.

Engineering Innovation: NASA is working to enable air and spacecraft designers to know with a high degree of confidence that their revolutionary designs will be safe and will achieve their mission objectives *before* they begin the costly process of fabricating and testing prototypes. To achieve this, NASA will develop advanced engineering tools and techniques that support "virtual" design processes. These include improved computer simulations to speed design cycles, intelligent networked information handling that enables designers at different locations to collaborate, development of radically new design cycle processes, and use of experimental aerospace vehicles to validate new concepts and technologies.

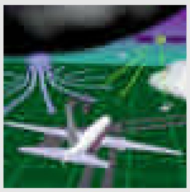
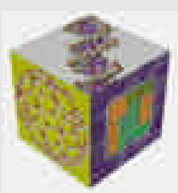
Technology Innovation: NASA intends to develop and apply cutting-edge technologies that will accelerate progress and change the definition of what is possible in aerospace. NASA will increasingly look to fields such as biotechnology, information technology, and nanotechnology to create advanced performance characteristics in structures and systems. The ability to build new aircraft and spacecraft structures at the molecular level, atom by atom, will enable greater strength, lighter weight, and lower costs. Miniaturized sensors and actuators embedded throughout vehicles will be able to detect, monitor, and even repair anomalies or failures. Combinations of these technologies may allow vehicles to change their shape. This "morphing" capability will permit better handling, reconfiguration of vehicles for different missions, and "self healing" in response to damage or component failure during flight.

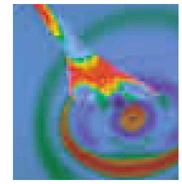
Goal 4
Commercialize Technology: Extend the commercial application of NASA technology for economic benefit and improved quality of life.

NASA technologies benefit not only aerospace but also numerous other industries such as surface transportation and medicine. It is essential that NASA technology continue to be made available to U.S. industry to augment our economy and benefit the public. To accomplish this, NASA provides the U.S. aerospace industry access to its unique facilities and expertise and establishes partnerships with the private sector and State and local governments. A continuing strategy to promote nontraditional applications for NASA technology is the NASA Commercial Technology Network. This network consists of NASA-affiliated organizations across the U.S. that help American enterprises in the transfer, development, and commercialization of NASA-sponsored technology. We seek to ensure the widest application of NASA-developed technology to benefit the Nation.

External Factors—Achievement of Aerospace Technology goals and objectives is particularly contingent on external factors pertaining to technological advances and partnerships. (See External Assessment)

The Aerospace Technology Enterprise—Roadmap

Goals	Objectives	Near-term Plans 2000–2005
 **Revolutionize Aviation Mobility:** Enable a safe environmentally-friendly expansion of aviation [2]	■ Increase Safety–Make a safe air transportation system even safer ■ Reduce Emissions–Protect local air quality and our global climate ■ Reduce Noise–Reduce aircraft noise to benefit airport neighbors, the aviation industry, and travelers ■ Increase Capacity–Enable the movement of more air passengers with fewer delays ■ Increase Mobility–Enable people to travel faster and farther, anywhere, anytime	■ Develop technologies to reduce the aviation fatal accident rate ■ Demonstrate technologies to reduce nitrogen oxide (NO_X) emissions ■ Demonstrate technologies to reduce noise impact by 5 decibels (dB) ■ Complete near-term advancements in terminal area productivity, and support the Federal Aviation Administration's National Airspace System modernization ■ Develop technologies for general aviation aircraft and infrastructure improvements and ■ Explore new innovative supersonic technologies
 **Advance Space Transportation:** Create a safe, affordable highway through the air and into space [3]	■ Mission Safety–Radically improve the safety and reliability of space launch systems ■ Mission Affordability–Create an affordable highway to space ■ Mission Reach–Extend our reach in space with faster travel times	■ Develop processes and technology improvements for safer crewed launches ■ Complete technology risk reduction to enable U.S. industry to significantly reduce the cost of launches to Low-Earth Orbit (LEO) ■ Develop advanced space transportation concepts, and initiate enabling technology programs
 **Pioneer Technology Innovation:** Enable a revolution in aerospace systems	■ Engineering Innovation–Enable rapid, high-confidence, and cost efficient design of revolutionary systems ■ Technology Innovation–Enable fundamentally new aerospace system capabilities and missions	■ Develop advanced engineering tools, processes, and collaborative teaming environments ■ Pioneer basic research in revolutionary technologies, such as nanotechnology, information technology, and biotechnology
 **Commercialize Technology:** Extend the commercial application of NASA technology for economic benefit and improved quality of life	■ Commercialization–Facilitate the greatest practical utilization of NASA know-how and physical assets by U.S. Industry	■ Increase the number and quality of technology partnerships with U.S. industry, and facilitate increased private sector access to NASA technical expertise and facilities



Mid-term Plans 2006–2011[1]	Long-term Plans 2012–2025[1]
■ Reduce the aircraft fatal accident rate by 80% ■ Reduce NO_X emissions of future aircraft by 70% [4], and carbon dioxide (CO_2) emissions by 25% ■ Reduce the perceived noise levels of future aircraft by a factor of 2 (10 dB) ■ Increase aviation system capacity to allow throughput to double ■ Reduce inter-city doorstep-to-destination transportation time by 50% in 10 years ■ Explore integrated supersonic transport designs	■ Reduce the aircraft fatal accident rate by 90% ■ Reduce NO_X emissions of future aircraft by 80% [4], and reduce CO_2 emissions by 50% ■ Reduce the perceived noise levels of future aircraft by a factor of 4 (20 dB) ■ Increase aviation system capacity to allow throughput at triple today's levels ■ Reduce inter-city doorstep-to-destination transportation time by 67% in 25 years, and reduce long-haul transcontinental travel time by 50% within 25 years
■ Reduce the risk of crew loss by a factor of 40 (to less than 1 in 10,000 missions) ■ Reduce the payload cost to Low-Earth Orbit by a factor of 10 and the cost of interorbital transfer by a factor of 10 ■ Reduce propulsion system mass, and reduce travel time for planetary missions by a factor of 2	■ Reduce the risk of crew loss by an additional factor of 100 (to less than 1 in 1,000,000 missions) ■ Reduce the cost to Low-Earth Orbit by a factor of 10 from today's costs ■ Enable bold new missions to the edge of the solar system and beyond by reducing travel times for planetary missions by a factor of 10
■ Demonstrate advanced, full life cycle design and simulation tools, processes, and virtual environments in critical NASA engineering applications ■ Integrate revolutionary technologies to explore fundamentally new aerospace system capabilities and missions	■ Demonstrate an integrated, high-confidence engineering environment that fully simulates advanced aerospace systems, their environments, and their missions ■ Demonstrate new aerospace capabilities and new mission concepts in flight
■ Design and implement innovative mechanisms to substantially increase the number and quality of technology partnerships with U.S. industry	■ Implement a systematic commercial technology program designed to contribute to the technology base of most of the key industrial sectors of the Unites States

1 In mid- and long-term timeframes, NASA plans to achieve a complement of enabling technologies that would allow the performance described in those columns. Integration of enabling technology into vehicles and operations will, however, take longer.
2 Using 1997 as a baseline (except as noted in 4).
3 Using 2000 as a baseline.
4 Using 1996 ICAO Standards as a baseline

The Manage Strategically Crosscutting Process

Through NASA, the American people have invested in an irreplaceable public aerospace research and development infrastructure consisting of a unique combination of physical resources and human talents. Managing these resources effectively and strategically is critical to achieving Agency goals and objectives. If a high-performance organization is to achieve its strategic objectives, it cannot simply practice good management; it must manage strategically. Ordinary good management entails responding to constituencies and customers, minimizing costs, seeking efficiencies, and investing in resources for maximum returns. By integrating these general management practices with management of our strategic processes we seek to manage strategically. Managing Strategically means that all parts of the organization proceed together coherently, comprehensively, and expeditiously toward the achievement of a single set of strategic goals. This requires that we leverage our limited resources; standardize processes where it makes sense to do so; streamline processes for timely results; and ensure rapid, reliable, and open exchanges of information.

Goal: Enable the Agency to carry out its responsibilities effectively, efficiently, and safely through sound management decisions and practices.

Objectives:

- Protect the *safety* of our people and facilities and the *health* of our workforce
- Enhance the security, efficiency, and support provided by our *information technology* resources
- Manage our *fiscal and physical resources* optimally
- Achieve the most productive application of Federal *acquisition* policies
- Invest wisely in our use of *human capital*, developing and drawing upon the talents of *all* our people

Safety and Health: Safety is critical to NASA's quest to expand frontiers in aeronautics and space. Safety is one of our four core values. NASA intends to become the Nation's leader in workforce safety and occupational health and the safety of the products and services we provide. Our strategy is to ensure that safety permeates every aspect of NASA work and that we routinely incorporate safety and health principles and practices into our daily decisionmaking. By focusing on the safety of NASA's mission and operations, we will also improve quality and decrease costs and schedules over the long run. Our safety priorities are safety for the public, astronauts and pilots, employees, and the high-value equipment in our care. The primary means by which we will achieve safety across these priorities are the following:

- Management commitment and employee involvement in preventing mishaps
- System and worksite hazard analysis
- Hazard prevention and control
- Safety and health training

We will also further develop our use of risk management practices to identify, analyze, plan for, track, and control risks, both to improve safety and to enhance the likelihood of mission success. As part of this effort, we intend to develop the U.S. Government's premier Probabilistic Risk Assessment capability.

Information Technology Management and Planning: The Manage Strategically Crosscutting Process includes NASA's Information Technology (IT) planning. This effort aims for optimal use of NASA's IT resources to achieve Agency goals and objectives. NASA's IT planning is built around four focus areas: Safety and Security (security and software management), Cost-effective Common Infrastructure and Services (services and solutions, architecture and standards), Innovative Technology and Practices (knowledge management, workforce challenge, and IT research and pilots), and Emerging IT Areas (e-business and e-government). NASA is undertaking an Agencywide IT security effort

encompassing: incident response and reporting, auditing and monitoring, penetration testing, risk assessments, security planning requirements, technology application, improved policy and procedures, and education and training.

Financial Management: To effectively manage our financial resources and evaluate Agency, Enterprise, and program-level performance, NASA is continuing to develop a new integrated financial management system. This system and other initiatives such as full-cost accounting will improve our financial and resource management.

Physical Resources Management: NASA's physical assets represent a significant investment of the American taxpayers. Good physical resources management supports NASA's vision and mission to further America's aeronautics and space programs. Our strategies to effectively optimize Agency investment strategies include: partnering, value engineering, outsourcing, performance-based contracting, energy conservation, recycling, and pollution prevention. This optimization dramatically increases the return on investment of NASA's scarce resources.

Acquisitions Management: NASA continues to improve the way we work with our contractors and to streamline acquisition regulations. Performance-based contracting and other initiatives are assigning contractors more program integration responsibility and accountability. Moving more NASA civil service employees from detailed operations management to review of contractor work allows us to enable the aerospace business instead of direct it. We continue to work to fully integrate small, small disadvantaged, and women-owned businesses into the competitive base from which we purchase goods and services, encouraging prime contractors to forge long-term, mutually beneficial business relationships with small firms.

Human Capital: Our human capital investment strategy begins with the recognition that employees are our most important resource. We must align management of that resource to best achieve our strategic goals and objectives. We will instill diversity in all that NASA does. As part of this effort we are working to attract and retain a world-class workforce with the necessary skills and competencies. Our strategies will include a combination of traditional hiring, more flexible employment arrangements, and nontraditional partnerships and collaborations. We will also encourage continual learning, including an emphasis on technical training, change management, leadership development, and career management.

To ensure that we retain a strong, skilled, creative, and effective human resources capability, we will periodically assess the effectiveness of our human capital policies, practices, and tools. Our human capital planning efforts strive to anticipate future challenges and workforce issues as NASA continues to move from operations toward more research and development work.

The Provide Aerospace Products and Capabilities Crosscutting Process

Through this process, NASA's Strategic Enterprises deliver systems (aeronautics, space, and ground), technologies, data, and operational services to NASA customers so they can conduct research, explore and develop space, and improve life on Earth. The process addresses the fundamental question: "What cutting-edge technologies, processes, techniques, and engineering capabilities must we develop to enable our research agenda in the most productive, economical, and timely manner?" The process strives to determine how we can most effectively and efficiently provide aerospace products and capabilities to our customers.

Goal: Enable NASA's Strategic Enterprises and their Centers to deliver products and services to our customers more effectively and efficiently.

Objectives:

- Enhance program safety and mission success in the delivery of products and operational services
- Enable technology planning, development, and integration driven by Strategic Enterprise customer needs

“It’s necessary for scientists and engineers to reach out to Americans, whc responsibility that we have to the future of this country.”

- Facilitate technology insertion and transfer, and utilize commercial partnerships in research and development to the maximum extent practicable
- Improve NASA's engineering capability to remain as a premier engineering research and development organization
- Capture engineering and technological best practices and process knowledge to continuously improve NASA's program/project management

To achieve the goal and objectives above, we will focus on the things we do best by strengthening NASA's role as a research and development agency. We will pursue our mission and goals aggressively, keeping each of our Strategic Enterprises moving forward at the cutting edge in their fields. We will ensure that the Centers of Excellence are preeminent in their areas of technical expertise. We will emphasize research and development and transfer operational activities, as feasible, to commercial operators, educational institutions, or other Federal agencies. We will continue to seek opportunities to privatize and commercially purchase goods and services that are not our main line of business.

We will develop cutting-edge technologies to accomplish our current programs more efficiently and enable new programs necessary to achieve our long-term goals. We will develop technology programs to realize our research and exploration goals, applying new technologies and capabilities to multiple programs. We will conduct more frequent missions for fewer dollars, thereby enabling increased opportunities for research, exploration, and discovery.

We will continually assess the process that governs the way our products and capabilities are realized. Learning from our failures and capitalizing on our successes, we will evaluate our approaches, modifying them when needed, in order to ensure adherence to sound and innovative practices. Attention to the Agency’s human capital through an expanded training initiative that provides timely formalized and experiential learning opportunities will enhance the ability of our people to perform in assignments of increased responsibility.

Heightened attention to thorough risk-management principles from inception of an idea through the end of its operations will increase our ability to maintain a healthy balance of our objectives with the needed resources. Reinforcing attention to an environment that values open communication will ensure decisions based on full knowledge. Collectively these efforts will further the Agency’s ability to do more with less as we strive to achieve our mission in ways that are faster, better, and cheaper.

The Generate Knowledge Crosscutting Process

This is the process by which NASA acquires new scientific and technological knowledge from exploring Earth, the solar system, and the universe, from researching biological, chemical, and physical processes in the space environment, and from aeronautics and astronautics activities. This process seeks to ensure that the science and technology funded by NASA is of the highest caliber. Customers for the product of this research include scientists, engineers, technologists, natural resource managers, policymakers, educators, and the general public. Generating knowledge is central to NASA's mission and is the primary means through which we seek the answers to our fundamental questions.

Goal: Extend the boundaries of knowledge of science and engineering through high quality research.

Objectives:

Improve the effectiveness with which we–

- Acquire advice from diverse communities
- Plan and set research priorities

ire our customers, because it is a fundamental
- Daniel Goldin, NASA Administrator

- Select, fund, and conduct research programs
- Analyze and archive data and publish results

To achieve the goals and objectives for this process, we will evaluate our research programs to ensure NASA's leadership in science and technology. We will collaborate with old and new partners. We will work with other Federal agencies, universities, and U.S. industry to complement and support our activities. NASA will continue to pursue mutually beneficial cooperative activities in aeronautics and space with other nations, strengthening American competitiveness, yet remaining consistent with the directive to encourage peaceful international cooperation contained in the National Aeronautics and Space Act of 1958 (the "Space Act"), 42 U.S.C. 2451, *et seq.*

The Communicate Knowledge Crosscutting Process

The Communicate Knowledge process is the means by which NASA coordinates, manages, and shares information and experiences related to the content, relevance, results, applications, and excitement of NASA's mission.

The Space Act mandates that NASA "provide for the widest practicable and appropriate dissemination of information concerning its activities and the results there of." The knowledge generated by NASA's activities is without purpose if it is not shared with those who can use it. This includes scientists and technologists around the world, companies and innovators, science and technology communicators such as educators, publishers, museums, and the media, and every citizen of the United States and the world.

NASA is a recognized leader for its innovative and comprehensive communication abilities. However, as an organization that focuses much of its attention on the successful completion of its programs and projects, we must remember that this is only part of our task. Our communication objectives are not secondary. Particularly as we strive to do more with less, NASA is committed to ensuring that we provide sufficient resources and attention to the vital task of transferring our discoveries outside of the Agency.

Goal: Ensure that NASA's customers receive information from the Agency's efforts in a timely and useful form.

Objectives:

- Share with the public the knowledge and excitement of NASA's programs in a form that is readily understandable
- Disseminate scientific information generated by NASA programs to our customers
- Transfer NASA technologies and innovations to private industry and the public sector
- Support the Nation's education goals

To achieve these objectives, we partner with the educational community and industry to inspire America's citizenry and create increased learning opportunities. We involve the educational community in our endeavors to inspire America's students, create learning opportunities, and enlighten inquisitive minds. We seek to share the experience of expanding the frontiers of air and space with the broadest array of America's citizenry. We will inform, provide the status of, and explain the results of NASA's programs. We will ensure consistent, high-quality, external communication.

In our communication efforts, we will seek to deliver content with value for our customers, not merely to promote our programs. We will constantly seek to understand what our customers value, rather than assume that we already know. Another strategy we will pursue is to better integrate the work of our communication professionals and our scientists and engineers. We will also leverage our information technology resources for knowledge management practices to enhance our communication efforts.

Cross-Enterprise Synergies

NASA's Strategic Enterprises comprise an integrated program in which each Enterprise helps to achieve NASA's mission. While many NASA programs are predominantly the responsibility of a single Enterprise, in many other cases, the Enterprises work together synergistically to contribute their unique expertise, technologies, and facilities to interdisciplinary activities. The following are just a few of many examples of collaboration among Enterprises.


Astronauts servicing the Hubble Space Telescope.

The Space Science Enterprise (SSE) provides information essential to the Human Exploration and Development of Space Enterprise (HEDS). This information includes scientific data about likely human destinations such as the Moon and Mars, surveys of space resources, and evaluations of space radiation hazards. SSE conducts missions in space and on other planets to test new exploration technologies that humans may use in these environments in the future. SSE findings are likewise helpful to Biological and Physical Research Enterprise (BPR) basic research in space. SSE also helps contribute to Earth Science Enterprise (ESE) activities; for example, SSE provides information on the genesis of solar radiation and other phenomena that affect the Earth's atmosphere. In addition, Space Science Enterprise's investigations of the nature of other planets help us better understand the Earth.

HEDS provides space and Earth scientists with valuable research opportunities. For example, SSE flies payloads on the Space Shuttle including telescopes to study the ultraviolet universe, instruments to investigate the solar corona and the solar wind, and cosmic dust experiments. The International Space Station will soon provide a new platform from which to observe both the Earth and space, and will represent the premier platform for BPR's laboratory research on life and physical sciences. Ultimately, some of NASA's most important and complex science goals, including determining whether life ever arose on Mars, may need to be addressed by HEDS' human explorers.

The Biological and Physical Research Enterprise conducts scientific and technological research that has far-reaching impacts for all the Enterprises. BPR works closely with HEDS to develop knowledge and technologies for maintaining human health in space. BPR's basic research in low-gravity fluid physics and combustion science will play a long-term role in AST's efforts to improve space transportation systems and space flight vehicles.

The Aerospace Technology Enterprise (AST) contributes significantly to the other Enterprise missions. For example, HEDS, SSE, and ESE will all benefit from the new launch and in-space transportation technologies AST is developing. Similarly, AST's aeroacoustics and aerodynamics expertise and the High-Performance Computing and Communications (HPCC) program contribute to both space and Earth science programs. AST's technology development and commercialization programs help each of the other Enterprises achieve their goals and objectives.

The Earth Science Enterprise provides essential context and baseline information for many of the other Enterprises' activities. ESE provides AST with assessments of the atmospheric effects of aircraft emissions. ESE's work reinforces SSE's efforts: ESE's studies of the Earth and its atmosphere, combined with SSE's research on the space environment, the Sun, and other stars and planets, help explain our planet's place in the universe and the potential for life beyond Earth. This is particularly evident in the new multidisciplinary field of astrobiology. Astrobiologists begin by studying basic life processes on Earth, particularly in extreme environments, then extrapolate to build simulations of the early Earth and present-day planets such as Mars. Based on this information and analysis, astrobiologists then derive predictive models of possible ecosystems on distant planets.

NASA's research on the Sun-Earth system is an example of synergy among all five Enterprises. The interaction between Sun and Earth, crucial to our lives in innumerable ways, is pertinent to the work of each Enterprise. SSE works to quantify the physics and behavior of the Sun and its effects in space; ESE researches the effect of solar variability on the Earth; HEDS and BPR use SSE research to mitigate the potential danger to astronauts from solar radiation; and AST designs air and space transportation electronics to better withstand solar radiation damage.

Integrated Space Transportation Plan

NASA is coordinating all of its space transportation efforts under a single investment strategy to ensure a smooth transition between today's Shuttle and tomorrow's advanced launch vehicles. NASA's Integrated Space Transportation Plan provides for continued Space Shuttle safety upgrades until an alternative to the Shuttle is operational, includes a near-term alternative to the Shuttle for access to the International Space Station, sponsors competitive industry development of a second-generation reusable launch vehicle, and invests in third-generation reusable launch vehicle technology.

The strategy makes maximum use of U.S. aerospace industry capabilities and commercial markets by including detailed investment options that industry believes are necessary to support market-based launch solutions. At the same time, it addresses requirements for future NASA-unique missions. This integrated strategy establishes the framework within which detailed Agency and industry technology requirements will be defined and investment priorities established.

Partnerships

A key NASA strategy is to establish and effectively utilize partnerships. We seek to partner with universities, other U.S. Government agencies, and industry where there are mutual benefits. We can significantly leverage our resources by benefiting from the interests, skills, and resources of others. Partnerships also bring our efforts closer in line with the needs of our customers. Examples of highly successful partnerships include: enlisting the space science community's expertise to help develop goals and objectives and assist with peer review; aeronautics technology development partnerships with industry; cooperation in Earth science applications with other agencies; and our space exploration and development partnerships with other nations.

Landsat 7 image of Pamlico Sound on the North Carolina coast, taken on September 23, 1999, shows higher concentrations of effluents due to extensive flooding from Hurricane Floyd.

Interagency Cooperation

NASA participates extensively in cooperative activities with other U.S. Government agencies. The table indicates the scope of this cooperation by partner agency and contribution to NASA goal. A number of these activities are coordinated through the President's Office of Science and Technology Policy and the National Science and Technology Council.

A key area of interagency activity for NASA is Earth Science. Among other efforts, NASA contributes satellite data and analyses to the U.S. Global Change Research Program, a multiagency, multiyear effort to understand the Earth system in order to better use Earth resources. NASA also has a long-standing, highly successful weather satellite partnership with the National Oceanic and Atmospheric Administration (NOAA). NASA's role is to develop new spacecraft and sensor technologies, while NOAA is responsible for operating the satellites. These spacecraft have for decades supplied key data for U.S. national and local weather forecasts.

NASA cooperates widely with other agencies in Space Science research and instrument development. NASA meets regularly with the National Science Foundation to coordinate cooperative space science research activities. The Departments of Energy and Defense have each made crucial contributions toward developing powerful sensors used on NASA's space missions. Recently declassified defense technology is of vital importance for future large space telescopes. In turn, NASA contributes to the mission requirements of other agencies. NASA research has, for example, helped protect defense communication systems from solar flares and magnetosphere phenomena.

NASA undertakes a wide range of collaborative activities in Biological and Physical Research. NASA has 20 active agreements with the National Institutes of Health (NIH) for joint projects to improve human health on Earth and in space. The most recent of these is with NIH's National Cancer Institute focusing on new approaches to detect, monitor, and treat disease. This cutting-edge effort uses biological models to develop medical sensors that will be smaller, more sensitive, and more specific than today's state-of-the-art surgical tools.

These new sensors will have applications for monitoring and treating astronauts on long-duration missions in space as well as for advanced health care on Earth. NASA works with the Department of Energy to study the effects of space radiation and will fly a Department of Energy experiment on the International Space Station to search for exotic forms of matter.

NASA cooperates extensively with the Department of Defense (DOD) and other Federal and State agencies on a variety of space launch and operations activities and in developing future Human Exploration and Development of Space capabilities. NASA, U.S. Air Force Space Command, and the National Reconnaissance Office coordinate a variety of technology development and planning activities through a Partnership Council. NASA, DOD, and other civilian agencies collaborate on future communications and data systems architectures for space operations through the National Security Space Senior Steering Group. Through the Interagency Global Positioning System (GPS) Executive Board, NASA participates with DOD and other civilian agencies to assure that the GPS meets overall space research needs. Interagency activities such as these ensure maximum compatibility among the agencies' spacecraft, instruments, and ground systems.

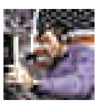
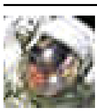
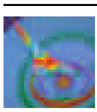
In Aerospace Technology, NASA works with many Federal agencies to achieve national objectives. For example, NASA participates in a multiagency effort to achieve a safer, more efficient, and more environmentally sound airspace system. NASA conducts cooperative programs with the DOD and the Federal Aviation Administration (FAA), capitalizing on the strengths of each partner. With the FAA, for example, NASA maintains a partnership in which NASA focuses on new technology while FAA works to bring the technology into operational use and develop standards.

Current work includes research on human factors, integrating activities in the cockpit with those in the air traffic control tower, more productive use of the airspace, environmentally compatible aircraft, and safety. Previous efforts focused on aircraft aging, ice formation on aircraft, and wind shear prediction.

This interagency planning and coordination occurs at all levels. NASA scientists and engineers collaborate directly with their colleagues from other agencies through professional conferences, workshops, meetings, teleconferences, joint projects, working groups, and personnel exchanges.

At the program management level, NASA program officials conduct meetings with appropriate officials from other agencies to coordinate programs and technology development work. At the Enterprise and Agency level, NASA is a member of numerous agency-to-agency committees that facilitate joint planning. These groups range from working groups to senior-level management committees. In some cases, such as with DOD, each agency assigns liaison staff to the partner agency. A key mechanism for planning with other agencies is use of Memoranda of Agreement to formally document cooperative activities and interagency commitments. NASA also participates in interagency planning meetings. At the highest level, NASA is an active participant in Administration interagency planning groups such as the National Science and Technology Committee and its Subcommittees.

Interagency Cooperation

NASA 's Strategic Enterprise Goals	Department of Agriculture	Department of Commerce	National Oceanic & Atmospheric Administration	National Institute of Standards & Technology	Department of Defense	U.S. ARMY	U.S. NAVY	U.S. AIR FORCE	National Imagery & Mapping Agency	Defense Nuclear Agency	Defense Reutilization & Marketing Service	Department of Education	Department of Energy
 ***Space Science***													
Understand the Universe		●	●		●	●	●	●					●
Support Human Exploration		●	●		●			●					
Develop New Technology	●	●	●	●	●	●	●	●	●		●		●
Educate & Public Outreach		●	●									●	
 ***Earth Science***													
Understand Earth Systems	●	●	●		●		●	●	●				●
Accelerate Economic & Societal Benefits	●	●	●		●				●				
Develop Advanced Technologies	●	●	●		●								●
 ***Biological and Physical Research***													
Conduct Research to Enable Exploration					●	●		●					●
Use the Space Environment as Laboratory				●	●		●						●
Enable Commerce	●	●		●	●		●	●					●
Education & Outreach													●
 ***Human Exploration and Development of Space***													
Explore the Space Frontier		●		●	●	●	●	●		●			●
Enable Humans to Live & Work Permanently in Space		●			●	●	●	●					
Enable Commercial Development		●		●	●	●		●					●
Share the Experience and Benefits					●	●	●	●					
 ***Aerospace Technology***													
Revolutionize Aviation		●		●	●	●	●	●	●				●
Advanced Space Transportation					●	●		●					
Pioneer Technology Innovation		●			●	●	●	●					●
Commercialization													

U.S. Department of Health & Human Services	Centers for Disease Control & Prevention	National Institutes of Health	Department of Interior	U.S. Geological Survey	U.S. Bureau of Mines	Department of Justice	Department of State	Department of Transportation	Federal Aviation Administration	RSPA: Volpe Nat. Transportation System Center	U.S. Coast Guard	Environmental Protection Agency	National Science Foundation	Federal Emergency Management Agency	Smithsonian Institute
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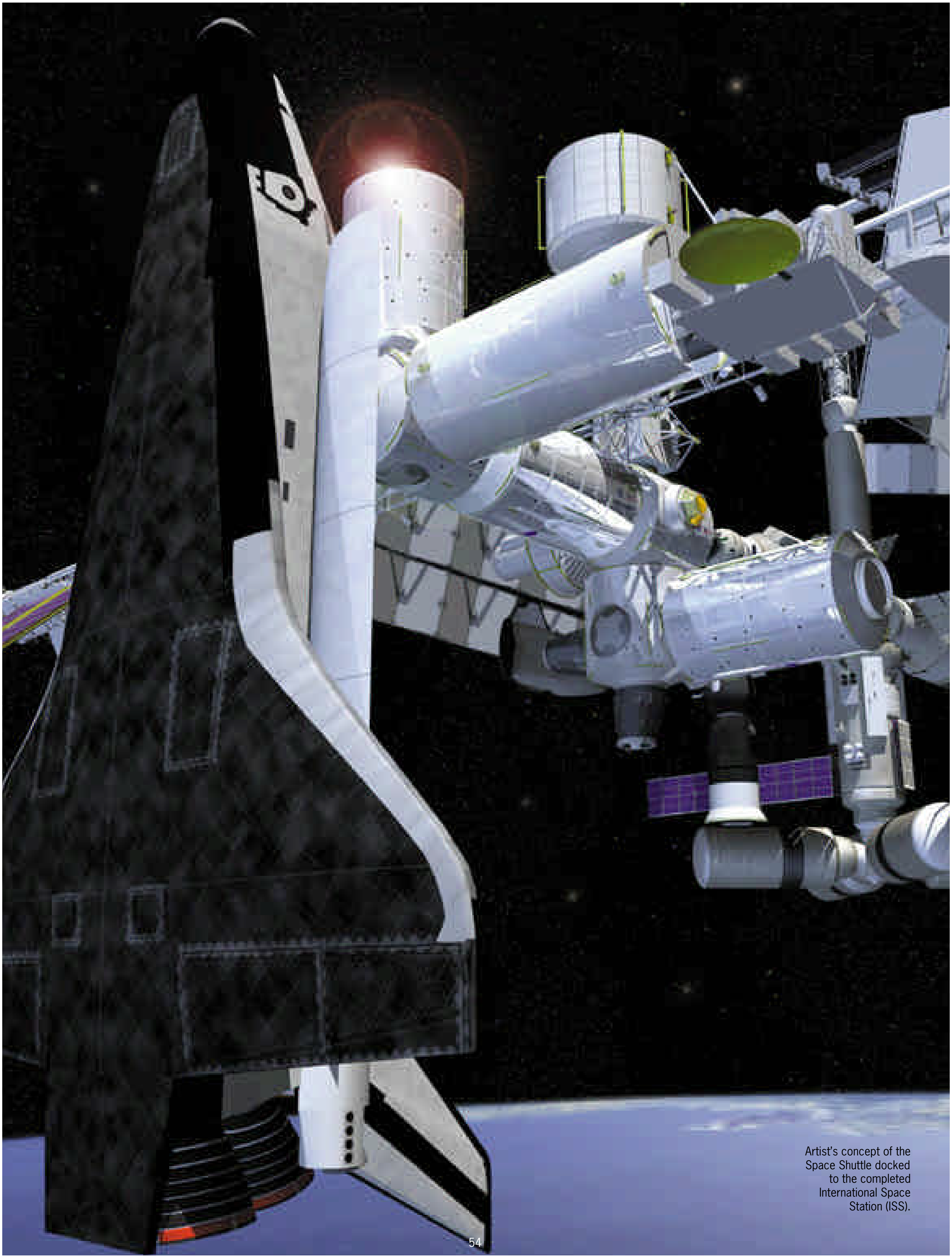

Artist's concept of the Space Shuttle docked to the completed International Space Station (ISS).

International Cooperation

International cooperation is an important component of NASA's activity. Since its inception, NASA has concluded over 3000 agreements with more than 100 nations and international organizations. International partnerships help NASA achieve its goals by providing access to unique capabilities and expertise, increasing mission flight opportunities, providing access to locations outside the United States, and distributing the costs of discovery. In addition, international space cooperation helps build and reinforce positive relations among nations.

The Space Act established international cooperation as one of the objectives of the civilian space program. NASA carries out this mandate consistent with broader U.S. policies (for example, economic, scientific, and foreign policy) and in accordance with specific NASA guidelines for this type of effort. NASA's international counterparts are generally government agencies. Projects must protect against unwarranted transfer of technology abroad. They must be appropriate, mutually beneficial, and offer significant technical, scientific, economic, or foreign policy benefits. They must contribute to NASA's program goals; contributions may include data, services, or contributions to flight missions or operational infrastructure systems.

NASA has well-established cooperative partnerships with other space agencies and continues to seek new opportunities for mutually beneficial cooperation with current partners, emerging space programs, and other appropriate government agencies. In addition to cooperation with other nations, NASA cooperates with international organizations such as specialized agencies of the United Nations. Currently, nearly all of NASA's Earth Science, Space Science, and Biological and Physical Research missions include international contributions in the form of scientific instruments, flight opportunities, or data analysis. For example, NASA's Earth Observing System satellites, Terra and Aqua, include scientific instruments from Brazil, Canada, and Japan. The Cassini mission, launched in 1997 and scheduled to arrive at Saturn in 2004, carries a NASA orbiter, a European Space Agency probe, and a communications system provided by the Italian Space Agency, and its scientific team includes representatives from the United States and 12 European nations.

Human Exploration and Development of Space programs include international crews on the Space Shuttle and International Space Station (ISS), international research facilities, and ground-based sites around the globe for operational mission support such as tracking stations and Shuttle emergency landing sites. ISS is the largest international science and engineering project NASA has ever undertaken, with contributions from Canada, 11 European nations, Japan, Russia, as well as the United States. This trend of highly international activities is expected to continue for the foreseeable future. NASA will continue to seek appropriate international partnerships to contribute to the accomplishment of our goals consistent with broader U.S. policies.

International Space Station Partner Agencies: Canadian Space Agency, European Space Agency, NASA, National Space Development Agency of Japan, and Russian Space Agency.

External Assessment

NASA's Strategic Plan describes the Agency's plans for the next 25 years. This distant horizon is appropriate and necessary, given the long-range nature of most of NASA's aeronautics and space activities and goals. Nonetheless, paradigms can change unexpectedly and radically over a few months or years, invalidating assumptions and making new plans necessary and possible. NASA sets long-range plans recognizing that it must be perceptive and flexible enough to evolve plans and programs as external realities change. The following is an analysis of factors beyond NASA's control that could influence our ability to achieve the goals and objectives in this plan. While some factors have a particularly strong effect on certain goals (see individual Enterprise sections), many of the factors affect almost all our goals due to the uncertain nature of long-term, cutting-edge R&D efforts.

Artist's concept of the Mars Global Surveyor.

The Legislative and Policy Framework: NASA's mission and goals derive from legislation and Presidential policy. In 1958, Congress passed the National Aeronautics and Space Act, establishing NASA and directing it to carry out specific purposes. A succession of laws and Presidential policies since then have from time to time redirected, expanded, or refined NASA's role. As a recent example, the Commercial Space Act of 1998, 42 U.S.C. 14701 *et seq*., significantly increased and promoted the role of commercial space activities; NASA's focus and goals have changed to keep pace with this new direction. Future law and policy may invalidate or reinforce current goals. Administration and congressional budget decisions also directly and significantly affect NASA's ability to meet the goals and objectives set forth in this plan. The objectives in this plan are consistent with the near-term budget estimates in NASA's FY 2001 budget request to Congress.

The Economy, Budgets, and Public Support: Closely related to the above

are two additional macro-level influences on NASA's ability to meet the goals and objectives in this plan. NASA assumes that the economy will remain strong enough to support the budgets necessary to meet its goals and to support commercial activities that are key to Agency achievement. Similarly, this plan anticipates that NASA will continue to experience public support and that citizens will continue to hold that a strong U.S. aeronautics and space program is important. NASA's own actions are an important factor in this equation. To win and keep public support, we must be accountable for our performance, explain our activities and achievements fully and comprehensibly, transfer technology as rapidly and beneficially as possible, and keep our goals and objectives in tune with the aspirations and needs of our customers.

Partnerships with Other Agencies and Nations: NASA conducts many projects jointly with other organizations, agencies, and nations. This plan assumes that our partners will be able to meet their commitments; failure to do so could slow or prevent achievement of our many joint goals. Consequently, in a few areas where the goal is particularly crucial, notably the International Space Station, NASA has developed alternate courses of action in the event that a partner is unable to meet a commitment. It should be reiterated that on balance, partnerships are highly beneficial to NASA and, in addition to providing cost savings, provide unique expertise and facilities.

Potential New International Partners: NASA's international partnerships reflect the scope of each partner's aerospace capabilities and interests and the U.S. relations with the nation in question. Changes in either factor can alter partnerships and thereby delay or accelerate goal achievement. Many nations are increasing their aeronautics and space activities; there are vastly more substantive national aeronautics and space programs now than there were 25 years ago. NASA actively welcomes new appropriate partnerships with other nations. Increased partnerships on missions that transcend national boundaries can enhance the U.S. ability to achieve aeronautics and space goals.

Markets: A related variable that could strengthen or confound NASA's ability to meet its space commercialization goals is the perception and reality of markets for space products and services, and industry's consequent willingness to invest in space ventures. Space presents enormous current and future business opportunities. In the past, NASA pioneered areas such as satellite technology that have led to profitable new industries that were unforeseen by most citizens and businesses at the time of NASA's initial activity. This pattern continues today. In 1997, for the first time, worldwide commercial space revenues eclipsed Government space spending, and in 1998, the number of commercial launches approached the number of Government launches. But predicting future markets is an extremely difficult task. For example, a major non-Government space policy study predicted in 1985 that, by 2000, global commercial space revenues would reach $51 billion and that the largest share of this would come from materials processing in space. In fact, global space revenues are double that estimate. In 1998, global revenues for the satellite industry alone totaled an estimated $66 billion. However, the largest share of this was Direct-to-Home television, a development that was unforeseen in the 1985 study. This illustrates the difficulty of predicting winning applications.

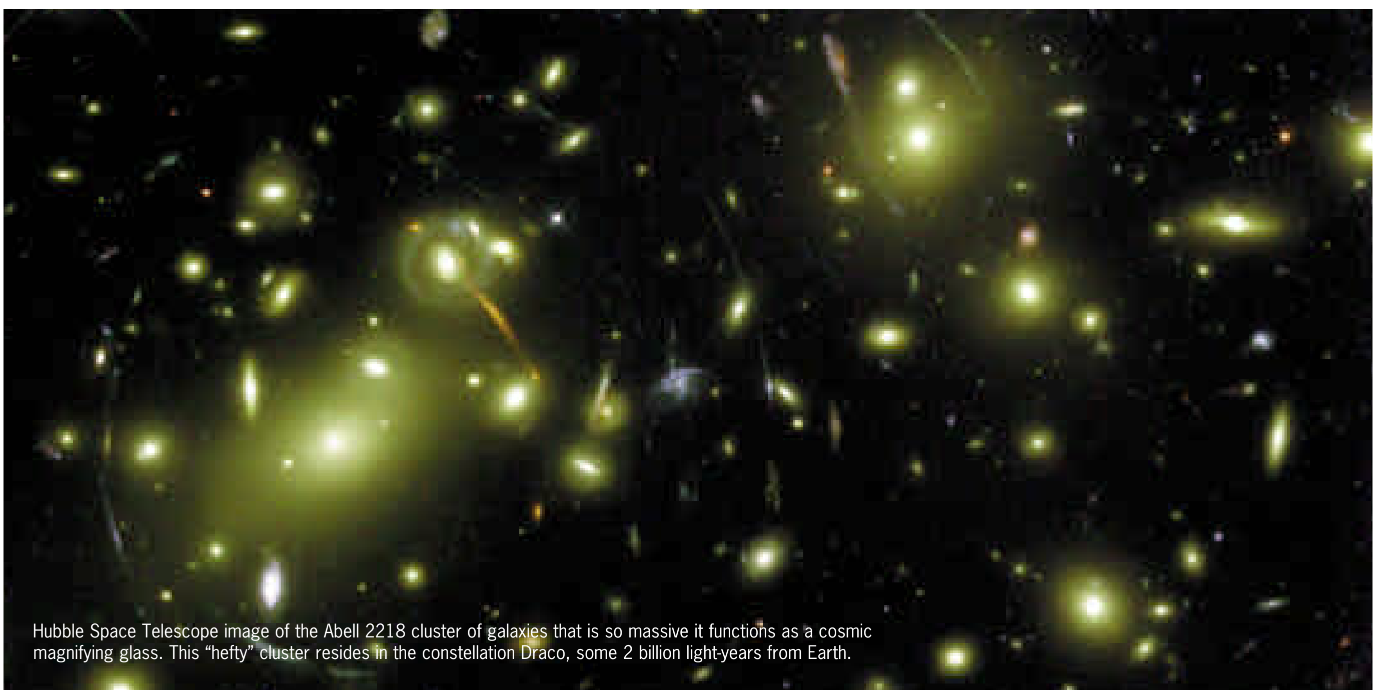
Many of NASA's space commercialization goals assume that industry will perceive potential profits from space activity and will invest to realize these profits. For example, several BPR and HEDS goals assume that industries will purchase accommodations on the International Space Station for new space ventures. To date, industry interest has been less than anticipated; this may slow

achievement of the related NASA goals. NASA remains convinced that it is essential to pioneer and help commercialize new areas of space activity to maintain the U.S. strong position in this growing and potentially limitless arena.

Technology: Many of NASA's goals rely on future technological breakthroughs—either precipitated by NASA or developed elsewhere and applied to NASA programs. A prime example of this is the need for revolutionary advances in propulsion technologies to improve air travel, deliver materials affordably into orbit, and send probes to other stars.

Because achieving breakthroughs is not a matter of applying known processes at prescribed rates of speed, we do not always know exactly how we will achieve a given goal and we cannot always specify when we will achieve it. Typically, however, the research and development efforts yield unanticipated collateral benefits that further other NASA goals and provide new technologies to assist industry and benefit the public. Thus, the unpredictability of technological advance can both delay and accelerate goal achievement.

Innovation and the R&D Base: A factor related both to the technological innovation discussed above and to the second demographic phenomenon outlined below is the capability to innovate. The Council on Competitiveness issued a study in 1999 statistically correlating a nation's innovative capability with specific factors, including the size of the R&D labor force, the amount of private investment dedicated to R&D, and the resources devoted to higher education. The study concluded that while the U.S. has long been the world's preeminent innovator, it is in danger of losing this status because other nations are doing a better job at investing in the fundamentals that support innovation. Maintaining our


Hubble Space Telescope image of the Abell 2218 cluster of galaxies that is so massive it functions as a cosmic magnifying glass. This "hefty" cluster resides in the constellation Draco, some 2 billion light-years from Earth.

innovative capability is central to U.S. economic strength and also to NASA's ability to achieve its goals.

Demographics: At least two major demographic factors may affect NASA's goals. First, the increase in the number of senior citizens may focus attention on specific aspects of NASA's work, especially those pertaining to medical applications. The great interest in John Glenn's Shuttle flight was a harbinger of this possibility. NASA aims to keep its goals as relevant as possible to its customers. Consequently, increased interest in space medicine—especially if accompanied by notable program success in this area—could result in amplification of related goals.

Second, NASA will continue to need an expert workforce over the next 25 years to perform cutting-edge science and engineering. The convergence of three large-scale factors may frustrate this: a reduction in the proportion of the population that is of working age, possible continuation of the economic boom with resulting tightening of the labor market, and continuation of the relatively poor high school performance and low graduate school enrollment of U.S. students in science and mathematics. Further, white males have traditionally comprised most of the Nation's scientific and engineering workforce, but they will be a smaller segment of the population in the future. More American women and minorities must become experts in science and engineering if the U.S. is to retain a competitive workforce. Will the U.S. be able to generate such a workforce? Will NASA be able to attract sufficient numbers of these workers?

A strong U.S. capability in science and technology is crucial not only for NASA but for the Nation as a whole. For this reason, each NASA Enterprise conducts vigorous education and outreach programs aimed at strengthening the science and technology interests and capabilities of all American students.

Discovery: NASA's goals and objectives constitute a balanced program of what the Agency sees to be valuable and feasible. However, new discoveries may change this program. For example, a greater level of certainty about the existence, extent, pace, and causes of global warming could either relax or intensify concern about this phenomenon, either diminishing or increasing support for related goals. Similarly, discoveries of other unexpected phenomena could result in new goals drawing resources away from the current program. To cite perhaps the most extreme example, a significant portion of NASA's work aims to find evidence of life elsewhere in the universe. Should this succeed, depending on what form the discovery were to take, NASA might radically reorient its goals.

NASA engages in research and exploration for the benefit of our customers—U.S. citizens and in a larger sense humankind. Our ability to achieve our goals and objectives depends on a changing calculus of resources, results, support, national priorities, partnerships, market forces, and other large variables. We aim to pursue our goals with dedication while remaining attuned to external changes beyond our control that could require further refinement of those goals.

NASA's Customers

NASA is committed to satisfying our customers. We have identified the following groups as our external customers and stakeholders:

- The Administration and Congress provide NASA the authority, policy direction, and resources to conduct the Nation's civil aeronautics and space programs. In addition, NASA is an investment in our Nation's future, and the Administration and Congress represent the interests of the future generations that will benefit from that investment.
- The science and education communities, aerospace and nonaerospace industries, Federal, State, and local agencies, non profit organization, and our international partners who receive our products directly.
- The public is both our ultimate resource provider and the ultimate beneficiary of our products.

To some degree our Strategic Enterprises focus on particular subsets of customers. Particularly important external customer groups for each Enterprise include the following:

Space Science
Science and Education Communities

Earth Science
Science and Education Communities, Commercial Sectors, Policymakers

Biological and Physical Research
Science and Education Communities, Commercial Sectors

Human Exploration and Development of Space
Science and Education Communities, Commercial Sectors

Aerospace Technology
Aerospace and Nonaerospace Industries, Federal Agencies

Consultation

In developing this Strategic Plan, NASA consulted extensively with our customers and stakeholders. These consultations built on the outreach and input activities that we conducted while developing our previous six Strategic Plans (from 1992 to 1999), including NASA Administrator Goldin's 1992 nationwide series of town hall meetings. An important source of consultations for NASA is industry workshops conducted by the Enterprises. NASA's science objectives are strongly influenced by NASA-conducted science workshops and studies by organizations such as the National Academy of Science. NASA's advisory committees (described under Evaluating and Reporting Performance) provide crucial outside expertise to aid in determining NASA's goals and objectives.

Interagency coordination for the many areas of collaboration and synergy between NASA and other Federal agencies (see Interagency Cooperation) establishes a framework for many of the Agency's plans. Extensive consultation with these Government partners in the context of the National Science and Technology Council, as well as through direct relationships, help shape NASA's goals, objectives, and strategies. NASA is active in interagency GPRA organizations such as the National Academy of Public Administration's Performance Consortium. Through meetings, conferences, and briefings, as well as direct exchanges of information, NASA consults with other agencies on the contents of its Strategic Plan and on general approaches to GPRA implementation Governmentwide. NASA has also conducted extensive meetings and briefings with our international partners and stakeholders in both programmatic and planning contexts. This plan has benefited from those ongoing consultative relationships.

In developing this plan, NASA conducted long-range planning workshops with cross-cutting collections of indirect NASA stakeholders. We collected data on NASA goals from secondary sources such as industry-led focus groups and polls. We evaluated the results of interviews with stakeholders, and conducted an analysis of rationales for NASA and its activities, based on outside polling, interviews, and focus group work. This plan represents comments received directly from NASA employees and members of the public, in response to previous versions and the draft version of this plan. We also conducted briefings, provided testimony and draft copies, and made changes in response to inputs from Administration and congressional stakeholders represented by the Office of Management and Budget, the Office of Science and Technology Policy, the General Accounting Office, and congressional staff and Members of Congress.

The American People are NASA's Stakeholders & Customers

The American people are the ultimate resource provider and the ultimate beneficiaries of investments in NASA's mission of research, exploration and discovery.

Congress and administration decision process responds to the public interest, votes, and funding resources.

NASA Enterprises serve primary customers in science, education, commerce, public policy, and in other Government agencies.

NASA Benefits: Create education excellence, economic growth and security, protect the environment, increase the understanding of science and technology, and peaceful exploration and discovery.

The NASA Team

The NASA Team is a dedicated, skilled, and diverse group of scientists, engineers, managers, and support staff. We work in partnership with industry, academia,other agencies, and the space agencies of other nations. The NASA Team is dedicated to achieving NASA's mission while maintaining the strongest possible commitment to safety, efficiency, and integrity.

Who We Are: NASA Headquarters, the Strategic Enterprises, and the Centers

NASA is comprised of Headquarters in Washington, D.C., nine Centers throughout the country,and a number of additional installations that support specific Centers. NASA also owns the Jet Propulsion Laboratory (JPL), which is operated by the California Institute of Technology under a contract with NASA.

The roles of Headquarters and the Centers are distinct. In carrying out the NASA mission, Headquarters determines what the mission is and explains why it is necessary; the Centers determine how we will implement it.

NASA Headquarters

NASA Headquarters develops, coordinates, and promulgates Agency policy. It sets program direction at the highest level. Headquarters has primary responsibility for NASA's communications with the Administration and Congress and is the Agency's focal point for accountability with external entities. It guides and integrates budget development, defines the Agency's long-term institutional investments, and leads and coordinates Agency wide functions.

The Enterprises

To carry out its mission, NASA has organized its programs into five Strategic Enterprises: Space Science, Earth Science, Biological and Physical Research, Human Exploration and Development of Space, and Aerospace Technology. The leadership of each Enterprise is at Headquarters, but implementation of Enterprise programs takes place at the Centers. Each Enterprise draws on the capabilities of several Centers, while each Center contributes to multiple Enterprises. The Enterprises communicate and coordinate with each other via Enterprise management at Headquarters.

The NASA Centers

NASA relies on its Centers to carry out the work of the Enterprises. Each Center has specific mission responsibilities and each is responsible for providing certain types of expertise and infrastructure. Centers are also responsible for assigned NASA-wide programs—overseeing their implementation and ensuring that they meet schedule, budget, safety, and reliability requirements. Finally, each Center serves as a "Center of Excellence" for a specific discipline; examples are structures and materials, information technology, and human operations in space. Centers of Excellence not only support immediate program needs but strengthen the long-term capabilities of the Agency and the Nation in critical areas.

NASA Centers:
Center Mission Areas and Centers of Excellence

NASA's Strategic Management System

To integrate planning and management of the Agency, NASA created the Strategic Management System. The system integrates our strategic planning, budget and performance planning, and performance evaluation processes with all other aspects of Agency management. This system is described in detail in the *NASA Strategic Management Handbook* (NASA Procedures and Guidelines #1000.2). NASA has aligned Agency management to correspond to the strategic architecture defined in this plan. To strengthen the Strategic Management System by ensuring that "we say what we will do, and that we do what we say," NASA has obtained Agencywide certification of compliance with ISO 9001 quality management standards.

Under the framework of the NASA Strategic Plan, NASA develops more detailed plans at each level of the organization:

Enterprises
Enterprise Strategic Plans

Headquarters Functional Offices
Functional Leadership Plans

Centers
Center Implementation Plans

Programs and Projects
Program and Project Plans

Employees
Employee Performance Plans

The NASA Strategic Plan is supported by annual budgets and performance plans that describe the resources necessary to achieve performance targets for the goals and objectives in this plan. Annually, NASA releases a performance report that indicates how the Agency performed toward achievement of the targets identified in the previous fiscal year's performance plan. The goals and objectives in this edition of our Strategic Plan form the basis for NASA's budget and performance planning, beginning with FY 2002. The NASA budget and performance plan will be released in the spring of 2001 for FY 2002 (which begins in October of 2001).

Performance Planning

NASA's performance measurement system gauges progress toward achieving the goals and objectives in this Strategic Plan. Annually, NASA releases a performance plan for the upcoming fiscal year with the President's proposed budget. The strategic goals and objectives from this plan are repeated in our performance plans with the performance targets and requested budget appropriations that support them. This direct relationship between performance targets and strategic goals and objectives meets the requirements of GPRA and allows our performance plans to demonstrate a clear relationship between Agency goals and measurable performance targets.

Due to the nature of aeronautics and space research, none of our strategic objectives can be attained in a year (barring unanticipated breakthroughs). As a result, many of NASA's annual performance targets reflect only incremental steps toward achieving our strategic goals and objectives. This is necessary given the legal requirement for annual performance plan targets. To help bridge the gap between annual activity and ultimate objective accomplishment, NASA has moved toward use of higher level performance targets in its annual performance plans (in turn supported by more detailed performance indicators). In addition, the roadmaps in this plan depict levels of accomplishment that are below the level of full Agency objectives but above that of performance targets for any 1 year. The roadmaps provide a useful planning tool to identify desired accomplishments over a 25-year time frame, at a higher level than captured by annual performance plans.

Evaluating and Reporting Performance

NASA's performance in developing and delivering products and services is evaluated at the Agency, strategic enterprise, functional office, program and project, crosscutting process, and individual levels. Each level has responsibility to execute requirements and to measure, evaluate, and report results. As each part of the organization completes its measurement process, data are used to validate that performance meets or exceeds planned goals, objectives, and performance targets. In those situations where performance does not meet the plan, opportunities for continuous improvement and reengineering are identified.

In the case of performance problems of particular concern, such as with the recent Shuttle wiring and Mars probe failures, special evaluations are performed and special mitigation programs are put into place. Results from efforts such as these are extensively

examined for implications for NASA planning at the strategic, budget, performance, and program levels. For example, in the case of the Mars probe failure reviews, the Agency was able to conclude that:

- our strategic objectives for Mars exploration remained valid;
- that our program management strategic objectives (contained in the Provide Aerospace Products and Capabilities Crosscutting Process) remained valid but required greater attention as well as alterations to our implementation strategies;
- that the budgets for projects within this program were inadequate for the expected schedules and levels of performance;
- that the performance measurement system in place was valid;
- that the future performance targets would be achievable later than anticipated; and
- that at the program level the Mars program needed to be completely redesigned.

This example demonstrates that while Agency planning establishes the framework for evaluation efforts, those evaluations provide critical feedback to shape Agency planning.

NASA uses a series of management councils to conduct ongoing internal evaluations. Throughout the year, Program Management Councils (at Headquarters and the Centers) assess program schedules, cost, and technical performance against established programmatic commitments. Twice a year, the Senior Management Council brings together Headquarters and Center Senior Managers to assess progress toward meeting Enterprise and Crosscutting Process performance targets. In addition, NASA's Capital Investment Council evaluates whether our investment decisions adequately support our goals and objectives and associated performance targets.

There are also regular reviews for functional management activities, such as procurement, finance, facilities, personnel, and information resources management. We also conduct reviews of science, engineering, and technology plans and performance, which include evaluations from Agency nonadvocate review teams, and the collection of thousands of technical performance metrics, schedule milestones, and cost performance data for flight programs such as the International Space Station. The Office of Mission Assurance conducts assessments to verify the robustness of safety and mission assurance processes throughout the Agency and performs independent assessments on selected programs that have need for a high level of assurance. In addition, the NASA Inspector General conducts independent reviews and provides recommendations for corrective actions.

In addition to our internal evaluation processes, NASA relies on significant external review processes. These evaluations include an extensive peer review process in which NASA uses panels of outside scientific experts to ensure that science research proposals are selected strictly on the merits of the planned research and expected performance. NASA also maintains a broad and diverse system of advisory committees under the Federal Advisory Committee Act, including the NASA Advisory Council and the Aerospace Safety Advisory Panel. The hundreds of science, engineering, and business experts on these committees provide external input into Agency management, programs, strategic plans, and performance. NASA advisory committees explicitly review and evaluate the Agency's performance reporting information, and the results of their evaluation are made a part of the Agency's Annual Performance Report. NASA also relies on evaluations from completely independent external organizations such as the National Academy of Sciences, the National Academy of Public Administration, and the General Accounting Office.

These extensive internal and external evaluation processes allow NASA to enhance its evaluation of the Agency's performance and to verify what revisions of Agency plans are appropriate. These evaluations are scheduled to continue on an ongoing basis.

Resources

NASA's budget and human resource planning processes are described in the *NASA Strategic Management Handbook*. Key strategic planning strategies for these areas are described under the Manage Strategically Crosscutting Process in this plan. Actual budget and human resources required to achieve the goals and objectives specified in this Plan are

NASA's Strategic Management System Documentation

contained in the President's most recent budget proposal for NASA.

This plan summarizes Agency activities for 2 fiscal years—FY 2000 and FY 2001, whose budgets have already been set. However, FY 2002 is the first budget and performance planning year for which this version of the plan is proscriptive.

The roadmap plans for 2000–2005 are consistent with estimates for those years included in NASA's FY 2001 budget request to Congress. While detailed budget projections have not been developed for mid- and long-term plans, NASA's planning framework generally assumes that resources provided by Congress will be neither less nor dramatically greater than current trends. However, the success of current programs, technology developments, and the success of commercialization efforts, as well as the other factors discussed under External Assessment, significantly impact the relative resources required to achieve a given set of objectives.

While this plan specifies NASA's general goals and objectives, it only generally specifies the relative importance of these objectives. It is the budget process which determines relative resource commitments across goals and objectives. The decisions of the President and the Congress in this regard have a large impact on the rate at which NASA can achieve particular goals or objectives. These decisions are, in turn, reflected when NASA selects the Agency's annual performance targets.

Acronyms and Glossary

accretion disks
Rotating disks of matter surrounding an astronomical object, such as a star, galactic nucleus or black hole, which is growing in size by attracting material.

AST
Aerospace Technology Enterprise

astrobiology
Study of the living universe. Provides a foundation for a multidisciplinary study of the origin and distribution of life in the universe, including the role of physical forces, planetary atmospheres, and ecosystem interaction in the evolution with living systems.

avionics
Use of electronics in all of its forms in airborne or aerospace vehicles.

biotechnology
Application of living organisms or biological techniques developed through basic research. Biotechnology products include antibiotics, insulin, interferon, recombinant DNA, and techniques such as waste recycling.

BPR
Biological and Physical Research Enterprise

Centers of Excellence
Focused, Agencywide leadership responsibilities in a specific area of technology or knowledge. The Agency-level designation calls for each Center's preeminence, with respect to the critical tools and capabilities associated with the particular area of excellence, in order to achieve the long-term strategic interests of the Agency.

Commercial Remote Sensing Program (CRSP)
Program for observation of the Earth from distant vantage points, usually by satellites or aircraft. CRSP analyzes pictures, extracts information, and enables the productive use of this information in private and public applications in environmental consulting, land use planning, and natural resources management.

coronal mass ejection
Huge cloud of hot plasma, occasionally expelled from the Sun. It may accelerate ions and electrons and may travel through interplanetary space as far as the Earth's orbit and beyond it; it is often preceded by a shock front. When the shock reaches Earth, a magnetic storm may result.

CSA/ASC
Canadian Space Agency/Agence spatiale canadienne

Direct to Home television
Direct TV transmission to home receivers via domestic satellites

DOD
Department of Defense

e-government
Electronic government–application of information technology by government. It involves four types of relationships—with citizens, businesses, employees, and other governments.

El Niño
Climate disturbance occurring every 2 to 5 years in the Pacific Ocean. A region of warm water forms in the western Pacific and moves toward South America, altering weather and rainfall patterns, wind directions, and even the jet stream. El Niño events contribute to floods and droughts in the Americas, Africa, and Australia.

EOS
Earth Observing System–A series of satellites that are a part of NASA's Mission to Planet Earth. These satellites observe multiple aspects of the planet, thereby enabling long-term comprehensive measurements of how components of the Earth system interact.

ESA
European Space Agency–Intergovernmental organization with 15 member states. Its mission is to provide and promote-for exclusively peaceful purposes, exploitation of space science, research and technology, and space applications.

ESE
Earth Science Enterprise

Europa Lander
Mission to Europa (Jupiter's moon) designed to study seismology and possibly penetrate the ice crust to reach liquid water ocean.

Europa Orbiter
Mission designed to study Europa (Jupiter's moon) in search of possible liquid water oceans beneath the ice surface.

FAA
Federal Aviation Administration

Federal Advisory Committee Act (FACA)
Act that governs the establishment of and procedures for committees that provide advice to the Federal Government. Advisory committees may be established only if they will serve a necessary, nonduplicative function.

FEMA
Federal Emergency Management Agency

Galileo Mission
Mission to Jupiter launched in 1989 to study its atmosphere, satellites, and surrounding magnetosphere for 2 years, starting in December 1995.

gamma rays
Electromagnetic waves of the highest frequencies known, originally discovered as an emission of radioactive substances.

GEO
Geosynchronous orbit–An Earth orbit that precisely equals the Earth's axial period of rotation (or any integer multiple or submultiple thereof).

GPRA
Government Performance and Results Act of 1993–GPRA requires Federal agencies to submit a formal performance plan with their budget submissions for each fiscal year. This is designed in an effort to enhance Government performance in the context of strategic planning and program implementation.

HEDS
Human Exploration and Development of Space Enterprise

High-Performance Computing and Communications (HPCC)
Program planned and implemented by Federal organizations. HPCC R&D is conducted at U.S. academic institutions, corporations, and Federal R&D laboratories. The National Coordination Office for HPCC coordinates the Program and outreach to interested communities.

Integrated Space Transportation Plan (ISTP)
Plan to identify and define NASA's 5-year investment strategy that will enable a low-risk, highly competitive selection of a new comprehensive space transportation architecture by the year 2005.

interferometry
Production and measurement of interference from two or more coherent wave trains emitted from the same source.

ISS
International Space Station–Global partnership of 16 nations. This Station represents a major engineering, scientific, and technological collaboration to greatly further human space exploration. ISS will include six laboratories and provide more space for research than any spacecraft ever built.

IT
Information Technology

L1, L2 / Libration points
Lagrangian points–In a system of two large bodies (Sun-Earth or Earth-Moon), these are the points where a small third body will keep a fixed position relative to the other two. In the Sun-Earth system, only two of five are important, both on the Earth-Sun line—the L1 point, and the L2 point at a similar distance on the night side. The L1 point is an "early warning" outpost intercepting shocks and particles emitted by the Sun and its vicinity has been occupied by several spacecraft.

Landsat
Land [remote sensing] satellite–Also known as ERTS. A series of satellites designed to collect information about the Earth's natural resources, first lofted in 1972.

LEO
Low-Earth Orbit–100 to 350 nautical miles above Earth.

Living with a Star
Multiyear program to understand space weather and the effects of the Sun on the Earth's climate. Its goals and objectives are linked to each of the five NASA Strategic Enterprises.

Lunar Prospector
First of NASA's Discovery class of "faster, better, cheaper" space exploration missions. It reached the moon in 4 days. Lunar Prospector's data gathering resulted in a series of discoveries and new scientific tools.

magnetosphere
Region surrounding a celestial body where its magnetic field controls the motions of charged particles.

Mars Surveyor Program
Long-term program designed to search for evidence of past or present life; understand the climate and volatile history of Mars; and assess the nature and inventory of the resources on Mars.

microgravity research
Area of scientific application and commercial research concerned with the identification and description of the effects of reduced gravitational forces on physical and chemical phenomena. NASA's HEDS program focuses on basic and applied research in five disciplines: biotechnology, combustion science, fluid physics, fundamental physics, and materials science.

microsatellites
Satellites with a total mass between 10 and 100 kg, often incorporating miniaturized electronic and mechanical systems.

nanosatellites
Satellites with a total mass smaller than 10 kg, incorporating miniaturized electronic and mechanical systems.

nanotechnology
Fabrication of devices with atomic or molecular scale precision. Devices with minimum feature sizes less than 100 nanometers (nm) are considered to be products of nanotechnology. A nanometer is 1 billionth of a meter; it is the unit of length that is generally most appropriate for describing the size of single molecules.

NASDA
National Space Development Agency of Japan

National Aeronautics and Space Act
Space Act of 1958 that founded NASA. It and its amendments call for NASA to: improve the usefulness, performance, speed, safety, and efficiency of aeronautical vehicles; establish long-range studies of the potential benefits, opportunities for, and problems involved in the activities for peaceful and scientific purposes; and preserve the preeminent position of the United States in aeronautical science and technology through research and development.

Near Earth Asteroid Rendezvous (NEAR)
Mission to answer fundamental questions about the nature and origin of near-Earth objects, including size, shape, mass and mass distribution, gravity and magnetic field, rotation, composition, and geology.

Next Generation Space Telescope (NGST)
It will eventually replace the Hubble Space Telescope. It is designed to use imaging and spectroscopy in the infrared to study the first stars and galaxies that formed after the universe cooled sufficiently to permit discrete structures to form.

NGO
Non-Governmental Organization

NIH
National Institutes of Health

NOAA
National Oceanic and Atmospheric Administration

NO_X
Nitrogen oxide–Any chemical compound containing only nitrogen and oxygen. Most are produced in combustion and considered to be atmospheric pollutants.

NSF
National Science Foundation

NSTC
National Science and Technology Council–
The principal functions of the Council are: to coordinate the science and technology policymaking process; to ensure that these policy decisions and programs are consistent with the President's stated goals; to help integrate them across the Federal Government; and to ensure that science and technology are considered in development and implementation of Federal policies and programs.

Office of Science and Technology Policy (OSTP)
President's Office created by the National Science and Technology Policy, Organization, and Priorities Act of 1976 to provide advice to

the President on issues relating to science and technology, as well as to coordinate Federal efforts in science and technology.

passenger throughput
Movement of passengers through a system in a given time or at a given rate.

PMC
Program Management Council–Agencywide council responsible for reviewing existing programs and projects, and new programs proposed by the Enterprise Associate Administrators as part of the annual budget cycle and making recommendations to the Administrator. PMC is a management tool in NASA's overall strategy to leverage fully programs, projects, and the budget.

Probabilistic Risk Assessment
Analytic tool used to assess the potential for failure and to help find ways to reduce risk in hardware development.

R&D
Research and Development

RSA
Russian Space Agency

Senior Management Council (SMC)
Consists of "Officials-in-Charge" at Headquarters and Directors of the Centers and JPL. This body provides advice and counsel to the Administrator. It is responsible for developing and approving the Strategic Plan, for evaluating performance against the annual GPRA Performance Plan, and for serving as a forum for the review and discussion of issues affecting Agency management and programs.

solar flares
Rapid release of electromagnetic (visible, radio, ultraviolet, x-ray) and particulate (protons, electrons) energy from the sun. Flares are classified according to the optically observed area of the solar surface covered, ranging from zero for the smallest to 3 for the largest, and their intensity, either faint, normal, or brilliant.

Solar Terrestrial Probes
Spacecraft being designed to uncover systemic properties of Sun-Earth interactions. Multiple units will work together to make simultaneous, coordinated, spatially separated measurements that will produce the first real-time, three-dimensional view of the structures that make up the solar, interplanetary, and terrestrial plasmas.

Space Act, The
See the National Aeronautics and Space Act.

Space Flight Operations Contract (SFOC)
It fundamentally reshapes the government/contractor management relationship and the responsibilities for Space Shuttle hardware acquisition, prelaunch processing, launch and landing operations, and flight executions. Under the SFOC, the private sector has responsibility for the day-to-day Orbiter, prelaunch, flight and ground operations, and logistics support. NASA, however, continues to have the final launch "go/no go" decision and ultimate responsibility for Space Shuttle safety.

SSE
Space Science Enterprise

Terrestrial Planet Finder
Mission of NASA's Origins Program that will consist of a collection of small telescopes functioning together to make extremely sharp images. Mission will enable a search for planets like Earth and for evidence of life there by carefully examining the colors of the emitted planetary light.

For More Information

For more information about NASA and its programs, visit: http://www.nasa.gov

For the NASA budget, performance plans, performance reports, the Strategic Management System Handbook, Enterprise Plans, Center Implementation Plans, Functional Leadership Plans or other information on NASA plans, visit: http://www.plans.nasa.gov

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NASA values the comments and recommendations of our stakeholders, customers, partners, employees, contractors, and the public. To comment on this strategic plan, please contact:

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Updates

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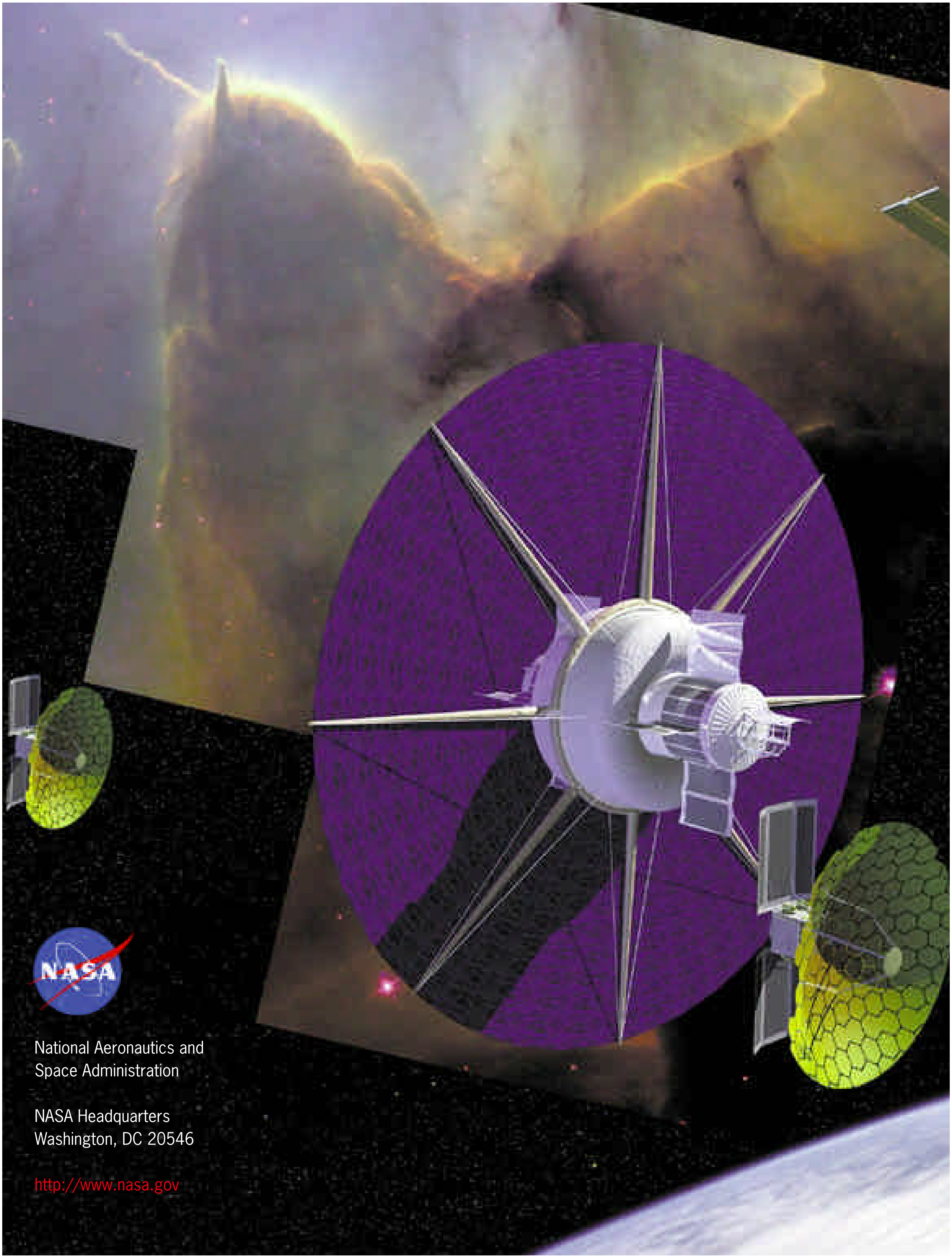
This plan will be updated on or before September 2003.

The most recent version of the plan can be found at: http://www.plans.nasa.gov



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